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THE ROYAL CANADIAN INSTITUTE

May 1915.

Botanical Series.

Vol. VII, No. I.

~~Biological
for Medical
etc.~~

Imperial Agricultural Review

Memoirs of the Department of Agriculture **STORAGE** in India

STUDIES IN INDIAN SUGARCANES, No. 1

PUNJAB CANES

BY

C. A. BARBER, Sc.D

Government Sugarcane Expert, Madras



PAR 4-1950

AGRICULTURAL RESEARCH INSTITUTE, PUSA

PRINTED AND PUBLISHED FOR

THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY

THACKER, SPINK & CO., CALCUTTA

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The Council of the Pusa Agricultural Research Institute.

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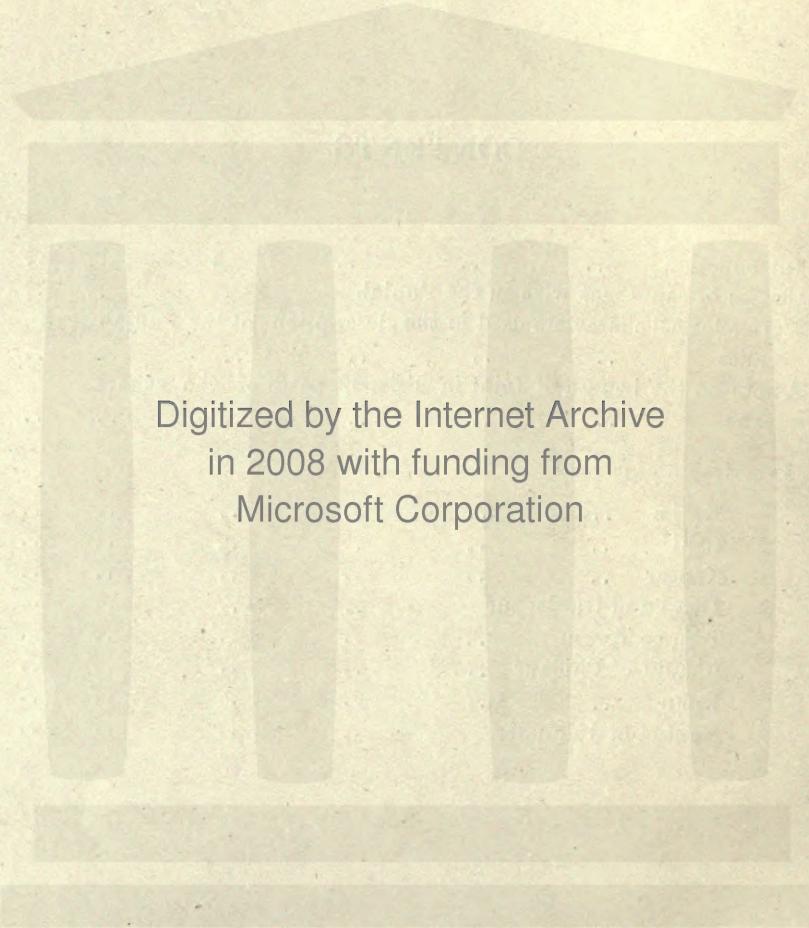
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INTRODUCTION.

THE multitude of varieties and complicated synonymy of the Indian sugarcanes, together with the frequent slight variations in the same cane in different localities, make a comprehensive study of these canes one of peculiar difficulty. It has been deemed advisable to commence with those of an isolated, more or less circumscribed area. The Punjab sugarcane tract is situated at the north-western end of the great submontane cane-growing area of North India extending from Assam and Bihar almost to Kashmir. In this tract large classes of canes are either ruled out by inclemency of climate or represented by solitary examples, the shortness of the period of growth and the incidence of frost being limiting factors. We have, thus, collected in the Punjab the smallest and hardest canes in India. They would also appear to be among the most primitive in the world and show marked resemblances to some of the wild grasses of the genus *Saccharum* in the same region. The study of the Punjab canes has, then, this further interest that it is admissible to compare some of the most primitive canes with wild forms, in the hope of solving the interesting problem of the origin of the sugarcane, at present found wild in no part of the world.

The Gurdaspur District of the Punjab has had most attention paid to it because of the existence of a Government Farm there and a collection of varieties of sugarcane grown on it for the last two or three years. This has been a fortunate circumstance,

because it would appear that the two chief canes of this district, the *Katha* and *Dhaulu*, are the ones which most closely resemble *Saccharum spontaneum*, *Kahi* or *Kans* grass, in the general trend of the morphological characters which form the basis of this paper. With the inflorescence we shall have nothing to do, as it is extremely rare that these varieties flower, but the stems and foliage have received a very careful analysis. I am told that there is a local tradition that *Katha* has arisen from *Kahi*. This may be due either to the obvious likeness between the two or to the actual handing down through many generations of the story of the selection of some form of *Kahi* with enough sugar content to make it worth while to give it intensive cultivation. There is no doubt that *Saccharum spontaneum* (Tamil, *Kurivi Naanal*) responds very quickly to cultivation, and this has been demonstrated in the plants grown at Coimbatore. Furthermore, it is an interesting fact that, while *Dhaulu* and *Katha* are separable by a number of minute differences, the specimens of *S. spontaneum* thus far examined appear sometimes to take after one and sometimes after the other of these two varieties of cultivated cane. Thus the stems of the grass are sometimes red and sometimes yellow, sometimes as thick as *Katha* or extremely thin; the plants may be prostrate or erect, the leaves narrow or broadish and the leaf sheaths spiny or smooth. The circlet of hairs is abundant or nearly absent; the buds vary from densely hairy to almost glabrous, from small and low down on the joint, to elongated and very high up, and so forth. This variability of the wild form as contrasted with the rigid inheritance of minute characters by the cultivated types is not difficult to understand. While the former is regularly propagated by seed, and is widely distributed throughout the different climates and geographical tracts of India, the two typical Gurdaspur canes have probably been grown in this locality for many centuries, and have always, to all appearance, been reproduced from cuttings, thus securing the continuance of the special morphological characters of their first seedling parent. An almost exact analogy is met with in the wild and cultivated peppers of South India. From a detailed study of the many varie-

ties present in the pepper topes of the Wynnaad, together with that of the whole of the wild forms of the Peninsula, it has been shown that many of the permanent types of cultivated pepper, such as *Balamcotta*, *Kallivalli*, *Cheriakodi*, have exact analogues in the examples of wild *Piper nigrum* collected on the Malabar Ghauts.¹ There is a common belief that the cultivated pepper has arisen from the wild or jungle pepper of this region, and, what is again striking, it has been shown that, for the production of seed, it is of prime importance that there should be an abundance of open anthers, a fact that is being made use of in the production of seedling canes at Coimbatore. Very few analyses have as yet been made of the juice of *Saccharum spontaneum*, but two seedlings raised from the same parent gave, on analysis, nearly three and nearly five per cent. of sucrose in the juice, besides varying greatly in habit and many other particulars. Two other facts may be mentioned as bearing upon the close relationship of the cultivated forms with *Saccharum spontaneum*. The two classes have been proved to be perfectly fertile *inter se* and numerous crosses have been raised with wild father and cultivated mother; and, secondly, among the seedlings of the indigenous Indian canes, there are occasional forms which would appear to "throw back" to such an extent that their similarity to *Saccharum spontaneum* is perfectly obvious. Seven such cases were met with in 180 seedlings of *Naanal* raised at Coimbatore in 1912-13, but it is not certain that the arrows of this cane were selfed.

The full study of the relationship of the Punjab canes with those of other parts of India has not yet been made, but it would appear that *Dhaulu* and *Katha*, themselves only differing in various small particulars, are connected with two series of canes gradually becoming thicker and more divergent as we arrive at better cane-growing conditions towards the south-east. Thus, related to *Katha*, we have *Lalri*, *Kansar*, *Chin* or *Chunnee*, *Baraukha* and *Saretha*, this series not apparently extending beyond the western

¹ Barber, C. A. "The Varieties of Cultivated Pepper." *Bull. III, 56, Department of Agriculture, Madras*, 1906.

parts of the United Provinces. From *Dhaulu of Gurdaspur* we have a much more extended series, commencing with the *Dhaulu of Ludhiana and Jullunder*, termed " *Dhaulu of Phillaur*" for convenience, and passing through *Dhaur, Bodi*, etc., to the great *Rheora or Mango* group, including many short thick canes typically present in Bihar. From certain morphological peculiarities it seems to me not impossible that this latter group forms a step between the indigenous canes of India and some of the thicker, cultivated, forms of the tropics, all traces of whose origin are at present, otherwise, lost in obscurity.

In these speculations it is however only right to point out that there are several tracts in India in which the *desi*¹ or indigenous canes have not as yet been studied. For instance, the solitary cane of the Central Provinces that I have seen, *Barhai* or *Barahi*, is obviously a cane closely related to *Katha*, which may have been brought down from the Punjab along the ordinary lines of migration. Then, there is the *Nargori* group of Bihar which, although evidently primitive, I cannot at present place. Less difficulty is likely to be experienced in regard to the occasional sporadic *desi* canes of South India, such as the *Naanal* of Madras and *Cheni* of Mysore. In no part of India which I have visited is the general facies of the canes of such a primitive character as in the Punjab, the smaller canes in other regions being rather the exception than the rule.

Sharply contrasted with the above hypothesis of the origin of the sugarcane in the part of India least suited to its growth, is the idea usually in vogue that the cultivated sugarcane arose from some wild form at the head of the Bay of Bengal, in Cochin-China or in the Malay Archipelago². I am not in a position to discuss the latter regions, nor are there any detailed descriptions of the wild *Saccharums* there. But the absence of intermediate stages in Bengal between such possibly primitive canes and the thicker ones

¹ It has been found comparatively easy to separate the indigenous canes of any part of India from those introduced from the tropical islands. Canes which lie between these two classes do not come into consideration in this paper.

² De Candolle. *Origin of cultivated plants.*

in general cultivation there suggests that, if this were the place of origin, the change from wild to cultivated forms took place *per saltum*, a theory which requires a good deal more to be said for it than that of a gradual evolution. If, however, such canes were brought into being as would repay cultivation in *this* region, they would naturally creep along the base of the Himalayas in the sub-montane tract, where soil and moisture conditions would permit of the crop being grown without irrigation. But, the climate becoming constantly less suitable because of increasing cold and a shorter vegetative period, the canes would become uniformly smaller and more difficult to grow, until, in the Punjab, the limiting factor of moderately sharp frost would put a stop to further migration and the canes would reach the lowest grade. Now such a migration is actually taking place every year. It is certainly true of *Saretha* and *Kanara*, the latter cane, now found as far as Jullunder being, it is said, occasionally wiped out by frost and, after such a year as 1908, only slowly reintroduced. A similar case is presented by *Kahu*, a solitary representative of the *Ganna* canes of the *Pansahi* group which reaches its maximum in Bihar. By the long continuance of this interrupted migration we should ultimately get a series of frost-resistant or semi-frost-resistant canes of small size, exactly as we now meet them in the Gurdaspur District.

Enough detailed information of the distribution of the desi canes of India has not as yet been collected, to favour either of these hypotheses to the exclusion of the other, but it is interesting to keep the two points of view in mind and it is hoped that, as time goes on and more regions are submitted to a careful study, a larger mass of facts will render possible a choice between assuming that the Punjab canes are direct descendants of some such form as *Saccharum spontaneum* and have given rise to the better canes of India, and that they are degenerate members of groups evolved elsewhere.

CLASSES OF CANES MET WITH IN THE PUNJAB.

The period during which I have been able to study the Punjab canes has unfortunately been short. It consists of three visits, between March 1913 and January 1914, to the Government Farm at Gurdaspur. A considerable number of canes have been collected there during the last few years, and these form the basis of the descriptions. It is pretty certain however that, as time goes on, other forms will be added, and the list of local canes increased. For instance, since my last visit, Mr. Southern has made the important discovery that the *Dhaulu* of *Gurdaspur* is not the cane grown under that name in the Jullunder and Ludhiana districts, and has sent samples of the latter to Coimbatore for examination. Any incompleteness of the list need not however deter one from describing those that have been examined, for, in order to detect such variations in the field, it is important that a full description of types should be at hand. The portion of the Punjab towards the United Provinces has not been at all fully explored and it is in this part that further varieties are likely to be found, but whether they are to be regarded as Punjab or United Provinces canes will depend on the opinion of the district agricultural officers. I have to record my appreciation of the great interest that Mr. Southern has taken in the purely morphological work which I have been attempting to do, and of his help in every possible direction. Through the kindness of Mr. Southern and Mr. Barnes, I have been able to place a certain amount of agricultural and chemical information in the first paragraph of the description of each cane. The paintings were mostly done on the spot by an artist lent by the authorities at Pusa, but a few were added by the artist of the Teaching Botanist at Coimbatore. The latter, whom I have trained myself, was also useful in making enlarged pen and ink sketches of my field drawings. I am responsible for the photographs. In

the latter the canes were placed on paper ruled with lines an inch apart, while, in the field, a bamboo is to be made out with a mark at about 6 feet from the ground.

The canes described in the present paper may be divided into the following classes :—

(1) *Katha, Lalri, Kansar*.—Thin to moderately thick canes with a brown colour largely diffused over the mature stems, heavily bloomed and therefore appearing pink or vinous or even violet, the brown skin showing strongly at the growth ring because of the absence of bloom there. These canes are closely allied to the *Chin* or *Chunnee, Lalri, Saretha* of the north-western portion of the United Provinces, but do not seem to have any relations further east. They are also represented in the Central Provinces by *Barhai* and doubtless others will be found in the elevated regions of the Deccan. The circlet of hairs at the node is strongly persistent in usually all the joints up the stem, the stems are cylindrical and straight, and the bud is small and rounded or pointed, reaching about the base of the growth ring.

(2) *Dhaulu and Tereru of Gurdaspur*.—Canes slightly thicker than *Katha* and differing from it in a series of minute characters. There is a comparative absence of the brown colour, suggesting a colour variety. The stems are glaucous green to clear bone yellow. The growth ring is marked, but of a light brown, and the circlet of hairs soon disappears entirely as we pass up the stem. *Dhaulu* in Gurdaspur district is grown on better land than *Katha* and is usually irrigated. I have at present met with no cane elsewhere belonging to this primitive class, but it appears to be related to the next.

(3) *Dhaulu of Phillaur*.—This cane shows sufficient resemblance to *Dhaulu of Gurdaspur* to warrant the suggestion that it has arisen from it. Thin, tall canes of a glaucous green colour, with zig-zag joints, a wide root zone and a very indefinite growth ring. The leaf scar is descending instead of horizontal as in *Katha* and *Dhaulu of Gurdaspur*, the circlet of hairs soon disappears under

the bud but is often traceable most of the way up at the back of the node. The bud is small and truncate, does not reach the growth ring and often only covers half the root zone. This cane appears to be almost identical with *Bodi* and *Dhaur* of the Meerut division and is an elongated, primitive form of the great *Mango* group of *Rheora*, *Hemja*, *Burli*, *Kuswar*, etc., of the United Provinces and Bihar. I have not met with canes of this class in other parts than those mentioned, and it probably does not extend into South India, but collections are at present incomplete.

(4) *Kanara* of *Jullunder*.—Bright green, soft canes much appreciated for chewing, often markedly oval in section, and apparently closely allied to, if not identical with, the *Kinar* of Meerut. Leaves very narrow. The circlet of hairs is constantly present and well developed. The bud is small and often squared, and does not reach the growth ring. The latter is well defined. It is interesting to note that this cane appears to be grown in conjunction with *Dhaulu* at Jullunder and, also, that *Dhaur-Kinar* is a constant mixture in Meerut. I am told that *Kanara* is occasionally completely wiped out by frost and that fresh seed has to be imported from across the Jumna. It seems reasonable to assume therefore that it is a migrated Meerut cane. I have not met with this cane, which is primitive in several respects, elsewhere than in the Meerut mixture, but there are many of the United Provinces canes still to be examined and it is too soon to speak of its further relationships.

(5) *Kahu*.—This cane stands by itself, in that it belongs to the *Ganna* class as contrasted with the *Ukh* canes thus far mentioned. A thick, juicy cane with protruding nodes and swollen root zones. The circlet of hairs persists only as a remnant of few long hairs under the bud. The joints are markedly zig-zag and have a well defined shape, which may be called ovate campanulate in the median view. The bud is large, ovate, pointed and extends beyond the growth ring, and there is frequently a cushion at its base. *Kahu* obviously belongs to the *Pansahi* class of canes, in which may be mentioned *Dikchan*, *Chynia*, *Yuba*, *Maneria* and *Lata*. It may be regarded as a migrant from the south-east.

MORPHOLOGICAL CHARACTERS USED IN THE DESCRIPTION OF THE PUNJAB CANES.

The list of characters dealt with in the descriptions is professedly far from complete. It is the result of a steady evolution in the study of the cane during the past year and a half, but omits certain characters recently noted. As there appeared to be no previous work done in this direction, I have had to start from the beginning and, as a consequence, the distinguishing characters have fluctuated a good deal in value at different times. The earlier canes examined (in the March visit) are, on this account, very incompletely described in my notes and the greater part of the description depends on the visits of September 1913 and January 1914. And it is to be noted that, even now, the stability of the characters mentioned is by no means assured. I have, naturally, confined myself to characters which would appeal to a botanical morphologist, but am fully aware that there are whole classes of field and mill characters of systematic importance which I have been quite unable to touch. Accurate figures for tillering, hardness of rind and its detachability, quantity of fibre, and other characters at the mill, must be dealt with by officers constantly on the spot and in charge of the milling operations.

It was hoped that, by growing canes at Coimbatore, a useful series of specimens would be obtainable whereby to check the observations made in the Punjab. Unfortunately, it has transpired that it is nearly as difficult to grow the North Indian canes on the Coimbatore Cane-breeding Farm as it is to grow thick, tropical canes in the Punjab.¹ In the former case, moisture and its availability in the soil appear to be the limiting factors while, in the latter, frost and the length of the growing period determine the

¹ This difficulty appears, I am happy to state, to have been now overcome (November 1914).

character of the growth. The further fact that the land at Coimbatore is at present alkaline as regards sugarcane growing may turn out to be of use, when it is possible to examine the Northern canes grown there, in testing the stability of the somewhat minute morphological differences which form the basis of the descriptions. The conditions of the two localities could hardly differ more widely, and the past year has been one of pronounced drought at Coimbatore, under 16 inches of rain having fallen in the twelve months. The descriptions of the cane contained in this paper have this advantage, that the canes have all been grown at the same place (Gurdaspur Farm) under identical conditions and examined at the same time. I propose now to give a summary description of the characters observed as this will save a good deal of repetition and make the descriptions more easily understood. For illustrations of the characters I would refer to the drawings of the different canes.

LIST OF CHARACTERS DEALT WITH.

1. GENERAL REMARKS AS TO DISTRIBUTION; AGRICULTURAL, AND CHEMICAL CHARACTERS.
2. LIST OF SPECIMENS EXAMINED.
3. GENERAL CHARACTERS OF THE VARIETY.
4. CANE MEASUREMENTS—
 - Dead leaves at six months old.
 - Length of cane and of shoot after stripping these.
 - Total length of cane and number of joints at six and ten months.
 - Total length divided by average thickness at middle.
 - Length of joints in different parts of the cane.
 - Thickness of the cane at various points.
5. COLOUR OF CANE—
 - General.
 - Bloom.
 - Growth ring.
 - Root zone.
 - Blackening.
 - Blushing.
 - Scar line or band.
 - Ivory markings, splitting.
 - Groove markings.
6. CHARACTERS OF THE JOINT—
 - Thickness, ovalness in section.
 - Length of mature joint (deducting top), average longest, average shortest (basal).
 - Shape viewed medially.
 - Shape viewed laterally.
 - Leaf scar and its ending, Lip.
 - Circlet of hairs.
 - Groove.
 - Root zone.
 - Growth ring.

7. BUD—

- Shooting, Bursting, etc.
- Size and Form.
- Origin and Cushion.
- Flanges.
- Bristles, Basal patches and Minute black hairs.

8. LEAFY SHOOT—

- Colour.
- Terminal tuft of leaves.
- Character of leaf ends.
- Number of terminal joints under 2" long.

9. LEAF SHEATH—

- Length ; average longest.
- Colouring, Bloom, Scarious border and edges.
- Hairs on back and on edges.
- Clasping stem.
- Proportional width of sheath and lamina.
- Ligular processes.
- Ligule and hairs on its edge.

10. LAMINA—

- Width and length, average extremes, and proportion of these to one another.
- Channelling, etc.
- Transverse marks.
- Serrature.
- Proportional width of midrib to lamina.

CHARACTERS DEALT WITH.

1. GENERAL REMARKS AS TO DISTRIBUTION AND AGRICULTURAL AND CHEMICAL CHARACTERS.

For this section I am indebted to Messrs. Southern and Barnes who have studied these aspects of the question on the spot. The section is capable of considerable enlargement. This is especially so in that I have come to the conclusion that there is no character of the sugarcane so stable as that which can be observed by a study of the field as a whole, the tillering, erectness, form of bunching, fall of leaves, angle of leaves to the stem, manner in which the ends of the leaves curve at different stages, blushing of the leaf sheath and stem on exposure, rooting and shooting, and any other marked peculiarity of growth—such are characters which can only be noted after a longer field study than has been possible.

2. LIST OF SPECIMENS EXAMINED.

This I have considered to be necessary, because it may well be that canes of the same name, found in fresh localities, will differ in some particulars. Such varieties will be of considerable interest as, thereby, we may be able to make a better chain of evolution, such as that hinted at in the Introduction, and will be of obvious use in testing the validity of the theories advanced regarding the origin of the sugarcane.

3. GENERAL CHARACTERS OF THE VARIETY.

This is intended to form a summary of the cane characters for general use. For instance, it may be of value in any doubtful case where an officer is touring and has not the opportunity of making a detailed study.

4. CANE MEASUREMENTS.

The subject of cane measurements is at present in a state of flux, as it has not been possible to determine how many canes should be examined in each case to obtain a fair average. Obviously, it is highly important that the specimens should be selected with great care, and the method adopted has been to take average mature canes from various parts throughout the field. The measurements taken during the September visit were confined to six cane shoots. This number will probably turn out to be insufficient. In January, 20 canes were measured and it is hoped that this number will prove ample, for the labour is excessive, not only in making the actual observations but in working out the averages. As will be seen from the note attached, these measurements of 20 canes have brought out some interesting facts. As regards the length of the joints in different parts of the cane, the canes in the field may be divided into two classes, and it is possible that this will ultimately be extended to the measurements recorded of other parts. The following are the numbers and measurements at present considered to be of varietal importance:—

(1) *Number of dead leaves at six months old.*

(2) *Length of cane and shoot after stripping these.*—These combined should, it is anticipated, give some criteria as to the rate of growth and rapidity of maturing of the different canes. It is seen that the more typically indigenous forms of the Punjab mature much more rapidly than such as appear to have been introduced from further east, where the conditions of growth are more favourable in a longer growing season.

(3) *Total length of cane at six and ten months after stripping all the leaves, and the number of the joints in each case.*

One of the most surprising features brought out by these measurements is the small growth in length and few joints added after, say, September. The canes are, to all intents and purposes, fully formed in this month.

(4) *Total length of cane divided by average thickness at middle, $l \div t$.*—It is hoped that the figure thus obtained will serve as a sort of index to the character of the cane. The tall thin canes characteristic of the Punjab will, presumably, have a very different figure from the thicker introduced ones. Thus *Katha*, *Dhaulu* of *Gurdaspur* and *Tereru* have index figures 156, 142 and 150, respectively; *Kansar* has 109; *Lalri* 81, *Kanara* 85, *Kahu* (thicker *Ganna* cane) 74; *Dhaulu* of *Phillaur* (an elongated *Rheora*-like cane) 97.

(5) *Length of Joints in different parts.*—At six months, only six canes were measured, but 20 were measured at ten months, when the cane was practically mature and growth had ceased. The curves obtained for these measurements have, as already mentioned, led to interesting results which will be further elaborated in a special note below.

(6) *Thickness of the cane at various points.*—The method finally adopted has been to measure the lowest joint, the middle one and the uppermost mature one. Sufficient numbers have not as yet been accumulated to draw any general conclusion, but it is probable that useful differentiating characters may ultimately be obtained from these measurements. The Punjab canes are, generally, characterised by considerable uniformity all the way up.

5. COLOUR OF CANE.

This has always been recognised as an important differential character in canes. In fact, all previous classifications, with which I am acquainted, use colour, whether green or yellow, red, ash-coloured, striped, etc., for the main divisions. That this is unsatisfactory is at once seen from the fact that the same stool has been seen with green, red and striped canes on it.¹ Furthermore, the colour of a cane changes very rapidly under different conditions, the *Kaludai Boothan*, a glaucous yellow cane of Coimbatore, developing a fine claret in Pusa. But colour is, none the less, an important character, and the canes grown long in any

¹ Barber, C. A. "The Origin of New Sugarcanes by 'Bud Variation.'" *Agricultural Journal of India*, Vol. I, Part IV, October, 1906.

locality assume quite definite tints which are of use in rapidly separating them at the mill. Thus the *Dhaulu* of *Phillaur* was at once distinguished in the *Kanara* plot in Gurdaspur Farm in January last, the canes being glaucous green instead of full green, and this led to the interesting discovery reported above that the *Dhaulu* of *Gurdaspur* is an entirely different cane from the *Dhaulu* grown further east in the Punjab. Colour is therefore always carefully noted.

Bloom is the layer of waxy hairs or scales which is met with in most canes, best developed at the top of the joints and there called the *bloom band*, but descending over the joint to a greater or less degree and influencing the general colour of the stem. Thus, when the skin is green the bloom renders it glaucous green, when the skin is brown the canes become tinged with a vinous or violet colour according to the relative strength of colour and bloom; a green stem without bloom gives a grass-green cane and so on.

The colour of the growth ring and root zone (see below) are also often characteristic. The former is rarely bloomed and thus usually stands out as a marked layer, especially in the canes of the *Katha* alliance where the skin becomes brown at maturity. The root zone is often bloomed and, usually yellow in these canes, becomes cream coloured.

Blackening, as if a layer of soot were spread over the joint, is due to the growth of a superficial fungus on the bloom (kindly examined for me by Mr. McRae, the Madras Government Mycologist). This discoloration occurs chiefly at the upper parts of the joint where the bloom is thickest. Incipient blackening often obscures the normal cane coloration.

Blushing is shown where the canes are tinged on exposure, e.g., where the leaf sheaths separate and one side of the joint is visible. The Punjab canes differ a good deal in this character, those of the *Katha* alliance hardly showing any change, while the *Dhaulu* section are readily tinged with red or violet. This leads to a curious paradox. The *Katha* canes are glaucous green at six months old but various shades of brown or violet when mature,

in fact the *Katha* cane is classified as a "red" cane. And yet, at six months, the *Dhaulu* is a "red" cane because of blushing violet and the *Katha* green because it does not blush. There is another form of coloration which has been insufficiently studied, namely, the tinge taken on by canes after being cut. *Dhaulu*, and especially *Kanara*, are seen, after a day or two, to be of brilliant pink red, while there is little change in *Katha*. What relation this change of colour in the cut cane has to blushing in the field is not quite clear, for I find that I have not noted blushing in *Kanara* in the field, although *Dhaulu* readily turns violet.

Scar band and scar line.—These marks are somewhat difficult to describe, but in certain canes a sharp, dark-brown line is seen immediately under the scar left by the fallen leaves. This line is above the bloom band. In others no definite *line* is seen, but a broader, less defined, greyish or brownish *band*, so that the bloom layer does not reach the leaf scar at the top of the joint. This is one of the differences between *Dhaulu* of Gurdaspur and *Katha* and would appear to have some connection with the circlet of hairs (see below) which is strongly present in the latter and very soon disappears in the former. In some examples the scar band is seen to be rough with minute hairs, or at any rate puberulous, and it may be that this roughness interferes with the deposit of bloom at this place.

Ivory markings.—This is the name given to the thin dark lines seen on the joints of so many canes. Although variable under different conditions, they are undoubtedly of diagnostic value. Sections through the epidermis show that these lines are in reality small splits and they are frequently accompanied by the formation of large, thick-walled cells below, as if placed there to prevent the deepening of the split or the entrance of fungus spores. The term has been used because of the resemblance of these lines to the markings on old ivory, but it is not very satisfactory. The ivory markings are often seen, in the Punjab canes, to give rise to visible splits in the rind, especially in the younger upper joints, and such

splits differ from the larger, deeper ones of other canes. The ivory markings differ as to their position on the joint. There are two main classes of arrangement in the Punjab canes. In some canes, such as *Dhaulu* of *Gurdaspur* and *Tereru*, the markings are chiefly confined to the middle of the joint and do not cross the bloom band ; in others, *Katha* and *Dhaulu* of *Phillaur*, they are commonest in the upper part of the joint and frequently cross the bloom band as small splits. In a good many canes they are present on the root zone, especially in lower, older joints. Not uncommonly ivory markings appear on a certain upper young joint in quantity, although hardly present elsewhere on the cane, and it is surprising how uniformly this occurs in the different canes of a plot. The significance of this is not understood. Cases have been noted where a cane without ivory markings in its normal habitat becomes covered by them when grown in another place, thus detracting from their value as a morphological character, and this is partly the reason why I have taken *Dhaulu* of *Gurdaspur* and *Tereru* to be really the same variety under different conditions.

The Groove markings (see below) are sometimes of peculiar character. The groove would seem to hold a position within the leaf-sheath to which minute organisms find easy access, but the causes of markings there have still to be worked out. A very common marking is a series of minute rounded bodies, brown at first but ultimately forming a harsh, black incrustation. It may be that these bodies are due to punctures by mites, but this point has not proved easy of determination. They are markedly present on many samples of *Saccharum spontaneum* (*Kahi*, *Kans grass*). Another marking is of a red brown colour and, under the lens, is seen to consist of a series of fine parallel lines of a brown red colour. And it is a curious circumstance that these red marks are not found in canes of the *Dhaulu* alliance while they are constantly present in all *Katha* canes. No idea has been formed as to their cause.

6. CHARACTERS OF THE JOINT.

I have found it convenient to make this popular term equivalent to the Botanical term "internode," the portion of the stem

between two leaf-scars. It is never used as meaning the node, but includes the bud with the portion of stem above it as far as the next leaf-scar.

Thickness, Ovalness.—The thickness of the cane has already been partially dealt with. But the measurements taken for the cane in general only deal with the comparative thickness in different parts, in fact the shape of the cane as a whole. In the earlier observations the joint itself was measured by calipers at various points, to wit, the leaf-scar, the root zone, the growth ring and the middle and top of the joint. But this has now been largely given up and, instead, the thickness has been taken in the middle of the joint in two directions at right angles to one another. Such measurements have demonstrated that the stem of the sugarcane is constantly oval in section, being narrower from side to side (laterally) than from back to front (medially). This is doubtless caused by the form of the shoot and the distichous arrangement of the leaves. But this slight ovalness can be ignored when comparing such canes as *Kanara* and *Katha* for, in the former, it can be seen at a glance that the cane is oval, whereas in the latter it requires the careful measurements by calipers before this can be determined. *Ovalness* therefore means, in the descriptions, such marked difference in the two measurements as can be readily detected by the eye. Canes of the same variety vary sometimes a good deal in the thickness of the joints in different parts and, as an index of thickness, the middle of the cane has been chosen. At least twenty canes have been measured, excepting in the earlier examinations. Ovalness is often noted as especially marked at the base of otherwise cylindrical canes and, more frequently still, in young swollen joints at the top. Such characters are detailed where observed, and it is seen that varieties differ a good deal with regard to them.

Length of mature joint; average longest and average shortest (basal).—This is not easy to formulate, because it is difficult to determine in each case where the mature joints end. For the purpose of this paper, joints at the top, under two inches in length, have been ruled out as immature, while all the basal joints have

been included. The results are thus the averages of fifteen to twenty joints of twenty canes, some four hundred joints, and it is hoped that this method will bring out the differences which undoubtedly occur in cane varieties. Canes vary much in thickness and length of joint under different growth conditions, but the figures given in this paper refer to canes grown in the same place and under the same field conditions, with the solitary exception of the *Dhaulu* of *Phillaur* discovered after the last visit to the Punjab.

Shape viewed medially.—This does not need much explanation. The point of view is with the bud in front, and this is termed the front of the joint, the other side, where the bud is absent, is termed the back. The thinner canes of Gurdaspur are generally long jointed and do not differ so much in the matter of shape as thicker ones, like *Kahu* or *Kanara*. And this fact will help ultimately to distinguish them from the canes of other parts of India.

Shape viewed laterally, that is with the buds in two series right and left. There are characteristic thickenings in the joints of the sugarcane which are often very slightly developed in the Punjab canes. *Kahu* is an example of a cane with such thickenings well shown, and the relative development in different parts of the joint helps to distinguish the different canes.

Leaf-scar and ending, Lip.—The leaf, when falling, does not come absolutely clear away, but leaves a narrow ridge behind. This is termed the *leaf-scar*, and is seen to be either horizontal, when viewed from the side, or descending towards the bud, and this difference is of considerable importance in cane classification. *Dhaulu* of *Phillaur* is, for instance, at once distinguished from *Dhaulu* of *Gurdaspur* by this character, the former having markedly descending leaf-scars which are horizontal in the latter. Sometimes a larger piece of the leaf-scar remains under the bud and this is termed the *lip*. The lip is not usually developed in the Punjab canes but forms a very marked feature in many others. The *ending* of the leaf-scar, being the outer end of the enveloping leaf-sheath, is some-

times marked. It is not usually met with in the Punjab canes except in *Kahu* but sufficed at once to separate *Sonabile* at Gurdaspur, and thus to discover the wrong naming of a cane called *Matna* on the Farm. In the cane mentioned (*Sonabile*), it is markedly decurrent and dark in colour, forming a sharp line as if drawn by a pencil across the leaf-scar at the side. It is, therefore, included in the general description of the cane.

Circlet of hairs.—I have been led to lay great stress upon the presence or absence of these hairs. If a young side shoot of the cane is carefully examined, it is seen that, when the leaves are torn off, a layer of close, parallel, fine, silky hairs is present at each node, the hairs arising immediately below the leaf-scar. When, however, a thick tropical cane is examined these hairs are rarely observable, although occasionally a few may be met with in the basal joints. Many of the indigenous Indian canes have these hairs very well developed right up the stem, and their presence seems to me to indicate a primitive stage in development. Their occurrence is probably a "youth character" from their constant presence on the young side shoots. But the Indian canes vary much in the relative persistence of the circlet of hairs. In *Katha* and its allies and in *Kanara* they are seen all the way up the stem, while in *Dhaulu of Gurdaspur* they soon disappear as we proceed upwards. In *Dhaulu of Phillaur* they disappear at a very early stage from under the bud, but are often traceable all the way up at the back of the node. In *Kahu*, on the other hand, they are only preserved as a few stiff long hairs under the bud. These differences are found to be fairly constant in any variety or indeed class, the circlet of hairs is always studied, and I have come to regard its relative persistence as a very important factor in classification. Such circlets or collars of hairs are often met with in grasses, and the wild *Saccharums* differ a good deal among themselves. Observations on the circlet of hairs may turn out of considerable value in tracing the origin of cultivated canes.

Groove.—This is the depression on the stem at the base of which the bud lies. It varies a good deal in different varieties and is

poorly developed in the indigenous Punjab canes. In some canes it is very strongly developed.

Root zone.—This is the region at the base of the joint whence the roots arise in germinating canes. The incipient or resting root tips are seen as clear round dots, and are often arranged in regular rows one above another, the lowest always being the largest and often the first to emerge. The width of this zone varies a good deal in different varieties, *Dhaulu of Phillaur* showing its likeness to the *Rheora* group by having a very broad root zone. The shape also is often characteristic, in that the thinner Punjab canes generally have flat root zones, even becoming thinner downwards, while *Kanara* and especially *Kahu* have protruding zones thickening bell-like downwards. The number, size and arrangement of the dots or eyes also vary a good deal. In *Saccharum arundinaceum* there is a single row of widely separated root eyes, in *Saccharum spontaneum* we have two or three moderately distinct rows as in the case of *Katha* and *Dhaulu of Gurdaspur*.

In *Dhaulu of Phillaur* the eyes are two to three deep, but it is often difficult to arrange them in rows, the lower ones being much larger and more distinct. The root eyes in *Namalu* and its allies in South India are very numerous and minute, as many as six or seven rows being sometimes seen. They also vary greatly in distinctness in different varieties.

Growth ring.—This is the representative of that zone, often swollen, in grasses by whose activity fallen shoots raise themselves, a zone of permanently active tissue where rapid growth may take place on either side of the stem, a zone of intercalary meristem. That this function is performed in the cane can be seen in almost any field of *Katha*, *Dhaulu* or *Saretha*, and in many other varieties, for wherever the cane is curving, the growth rings are wider, and especially so on the lower side of the stem. But I have met with a number of cases where the growth ring does not appear to be very active, especially in the thicker canes of South India. Here severe curvatures of the stem are sometimes due to a direct bending

of the stem above the growth ring. The growth ring is situated immediately above the root zone, at the base of the joint. It is usually devoid of bloom (although waxy scales are sometimes seen on it), even when the root zone is covered, and is thus frequently marked out by its colour, as in *Katha*, *Chin*, *Saretha*, *Kansar*, &c. In North Indian canes it usually has definite upper and lower boundaries, but in *Dhaulu* of *Phillaur*, it is often difficult to see it at all. This is even more so with *Rheora* and its allies, and in this respect they agree with most of the thick canes of the tropics.

The growth ring is thus of considerable importance in classification, and its study has led to the suggestion that, if the tropical canes are derived from indigenous Indian ones, it may be along the line of the shorter, thicker, broader-leaved *Rheora* group.

7. BUD.

From a study of these in many canes, I have been led to lay high value on the character of the bud in classification. This is not to be wondered at when it is considered that the bud contains the characters of the shoot in embryo. I have had to invent various terms for the different parts, some of which may not be well chosen, but there has not at present been time for a thorough morphological study of the bud. The size, form, point of origin and vestiture are the chief ways in which the buds of different varieties may be distinguished.

Shooting, Bursting.—The cause of the shooting or emergence of the buds has not been properly studied at present. That it may have something to do with free percolation of moisture is suggested by the enormous development of this character in canes sent from Samalkota to Pusa, where unaccustomed ease was doubtless experienced by the roots in obtaining the water in the soil. But different canes vary much in the amount of shooting and, some of them in the place where shooting takes place normally. Observations on this phenomenon have not at present been possible in the canes described in this paper, and the matter has to be much more

carefully studied before any conclusion can be arrived at as to the permanence of the character under different conditions.

Bursting is the term applied to the point at which the apex of the bud emerges. For determining this it is not necessary for the apex to have shot out, for the arrangement of the bud scales and their venation in the resting condition will give the necessary indications. As a general rule, elongated buds burst apically, whereas rounded or truncated buds emerge from the middle of the back, or dorsally. There are all stages between these two and the character of bursting is usually more or less constant, although the upper younger joints have more elongated buds, with the corresponding change in the point of emergence.

Size, Form, etc.--Here, again, we meet with great diversity among cane varieties, whether Indian or tropical. The buds of *Katha* and *Dhaulu of Gurdaspur* are rather small, but they cover the root zone and extend upwards to the growth ring. In *Dhaulu of Phillaur*, on the other hand, they are usually truncate and do not nearly reach the growth ring because of the broad root zone. In *Kahu* they are very large and pointed and extend beyond the growth ring in most joints, while in *Kanara* they are rounded or squared and do not reach the growth ring, although the root zone is not broad. In *Poovan*, a thick South Indian cane, they are very small and rounded while in *Kaludai Boothan* they are broad and large. These and other characters of the buds are usually fairly constant for the variety and it is one of the most convenient characters by which to determine doubtful canes at the mill.

Origin and Cushion.--The buds are protected by the base of the leaf, termed the leaf-sheath, and in the growing shoots are completely hidden from the outside world. When the leaves are stripped, it is seen that the buds are usually placed immediately above the leaf-scar and often partly covered by it. In other cases, however, as in *Kahu* and some upper joints of *Dhaulu of Gurdaspur*, they arise at some little distance above the leaf-scar. When this

occurs there is sometimes a small area between the bud and the leaf-scar, more or less sharply marked off by two downward curving lines, which is devoid of hairs or root eyes. This is termed the *cushion*, and it is typically developed in the *Pansahi* group of which *Kahu* is a member.

Flanges.—The two opposing lowest bracts or bud scales generally have, on either side, scarious borders which are termed flanges. These vary a good deal in different varieties. Their point of origin varies. In the elongated buds they often arise low down and in the circular or truncated buds they usually arise above the middle. They are continued, as a frequently dark-coloured margin, round the apex of the bud and are there either pointed, rounded, truncated or even emarginate, modifying the shape of the bud in this direction. In *Namalu*, a thick Coimbatore cane, they are produced into a long beaked process beyond the apex, in *Kaludai Boothan* they are very broad at the sides and often auricled, while in *White Mauritius* they are developed into two broad scarious wings which are very characteristic.

Bristles, Basal patches, and Minute black hairs.—The vestiture of the bud is of considerable interest, although the exact homology of the different forms of hairs has not yet been worked out. The flanges are more or less coated with stiff, long, straight hairs, often projecting to a considerable distance beyond the apex of the bud. These are called *Bristles*. Sometimes there is a marked tuft at the base of the flange, at other times the bristles are confined to the inner sides or to the edges.

The sides of the bud below the origin of the flanges have hairs of another kind. These, when typically developed, are arranged in parallel lines and strongly recall the circlet of hairs, with which they are perhaps homologous. They are often white in colour and more or less crisped, very delicate and closely pressed to the sides of the bud. Their general direction is that of the nerves on the scales and they not infrequently merge into a series of hairs on the veins. Sometimes they are continuous, on the other hand,

with the bristles of the flange or the tuft of these at its base. In many varieties these *Basal patches* are poorly developed or even absent and sometimes their place is taken by a puberulousness or by minute black hairs.

Minute black hairs are common on the bud in many varieties. They appear to be always present on *Dhaulu* of Gurdaspur, while hardly ever observable on *Katha*. They are usually most developed on the veins of the bud scales, at the apex of the bud or in the region of the basal patches, but they may also occur at any part of the bud. Such minute black hairs are a constant feature of the base of the leaf-sheath, between the veins, and are not infrequently found in the scar band, making it more dusky in colour.

8. LEAFY SHOOT.

Observations on this part of the cane have not been properly worked out. The colour, the arrangement of the leaves along the stem, the character of the leaf tip, the manner of clustering at the end and other characters of the shoot, can only be studied in plants in full vigour, and the opportunity has not yet occurred for doing this thoroughly. The bunch of leaves at the end of the shoot is usually described under the term *terminal tuft*. I have included in this the number of visible leaves arising on the last 2" of the shoot. The number of leaves in the terminal tuft is largely dependent on the rate of shortening of the end joints in the cane, because one leaf is borne at each node. Accordingly, the lengths of the end joints of the cane are entered here, down to one-tenth of an inch, beyond which it has not been found safe to go. There is no doubt that canes vary much in the number of leaves in the terminal tuft, but a study of the figures obtained from the canes six and ten months old has made me cautious as to generalising. Taking the number of joints to be passed from the apex before a two-inch length is reached, it is easy to see that there are a great many more in the older canes. In other words, the rate of growth in length of the cane is greatly diminished.

9. LEAF-SHEATH.

It is surprising how many characters of classificatory importance can be drawn from a study of the leaf-sheath. This part is homologous with the bud scales and there too we saw that quite a number of characters could be made out with careful observation. Some of the characters mentioned below have not been fully studied but they are mentioned in the belief that they will ultimately prove useful.

Length, average longest.—The length of the leaf-sheath, or lower sheathing portion of the leaf, varies a good deal in different varieties. Thus, the sheath in *Kahu* and its allies is short, rarely exceeding 10—11 inches, while that of the *Rheora* group reaches or even exceeds 15 inches. The average length of the sheath has been taken of the six canes examined at Gurdaspur six months old. It is not possible to do this much later, as the older ones rapidly become broken. But this method has the disadvantage that the growing period has not ceased and, while it lasts, there seems to be a constant tendency towards the increase in length both of sheath and lamina. The average longest is therefore added to the figures.

Colouring, Bloom, Scarious border and edges.—The colouring of the leaf-sheath has not been very uniformly noted in the varieties. But the *Kahu* group show characteristic purple blotches, possibly due to a special fungus invasion. The fact that certain varieties of canes are attacked by special fungus or insect pests is constantly borne in on one, and there is a mass of work to be done in this direction because such attacks are of obvious classificatory value. The markings, lines, blotches on the leaf-sheath are probably a case in point. Bloom is often present on the leaf-sheath, but not always, and *Katha* and *Dhaulu* of Gurdaspur differ in this respect. When the sheath is mature and commences to dry up, this usually happens along the edges first. There is frequently a discontinuation between the lamina and leaf-sheath at the point of junction, the leaf-sheath being wider; and thus the decay of the edges of the leaf-sheath is probably connected with disuse in no longer passing up water

to the lamina or with decay for lack of nutriment passing downwards. The different kinds of sugarcane differ remarkably in the early appearance of this dried up, *scarious border* and, although it is most often found in the thicker tropical canes, it is always well to note it. The *edges*, lastly, of the young leaf-sheath sometimes assume definite colour. In *Dhaulu* the edges soon become red brown while in the *Katha* family they are more or less light coloured and transparent.

Hairs on back and on edge.—This includes, generally, the vestiture of the leaf-sheath, the inside being smooth and shining. Many of the sheaths are well armed with silicious spines variously distributed over the back; all have minute hairs between the veins behind, so minute in most cases that they are a mere puberulousness, and these hairs are usually black below and white in the upper part of the sheath. There are tufts of long silky hairs on each side where the sheath joins the lamina. The development of these varies a good deal and they sometimes extend down the edge of the sheath for some distance. Besides this vestiture there are various kinds of roughnesses which have not been studied in the Punjab canes.

Clasping stem.—This refers to the base of the leaf-sheath, where it is fixed to the stem. It is sometimes very wide, as in *Katha*, where it clasps the stem for one and a half times its circumference; in *Dhaulu*, on the other hand, it is proportionately narrower and clasps the stem only for one and a quarter times its circumference. This is seen in the plates of these two canes.

Proportional width of sheath and lamina at the point of junction, Ligular processes.—The relative width of lamina and sheath has been found to be of some importance in diagnosis. It is connected with the scarious border referred to above, but more especially with the ligular processes. As stated above, the sheath is usually wider than the lamina. If this excess is greater than 25 per cent. there is usually an extension upwards of the sheath as a

separate outgrowth. This is called the *Ligular process*, and often occurs on one side only, namely, the inner. The presence or absence of ligular processes, depending as it does on relative width of sheath and lamina, is a very useful character, and serves almost of itself to divide the Indian canes into sections. Thus, in the *Pansahi* group ligular processes rarely occur, whereas they are constantly present in the *Katha-Chin* group. *Dhaulu* of *Gurdaspur* may be distinguished from *Katha* by the absence of the ligular process, and so forth. Sometimes the processes attain a very large size and are very striking features on the shoot. A recent seedling at Coimbatore has ligular processes over $6\frac{1}{2}$ inches long. As to their exact morphological value, after careful examination, I have come to the conclusion that they may equally well be called "ligular" and "stipular" but, because of the comparative absence of the latter organs in the Monocotyledons, and the fact that they are in direct continuation laterally with the ligules, I have adopted the former term. They may, for the present, be considered as lateral expansion of the ligule. Thus they have nothing to do with the outgrowths of *Oryza*, *Hordeum*, etc., which are expansions of the base of the lamina, but are practically equivalent to the ligular expansions in *Ammophila arundinacea*, with the middle part remaining short while the two sides have grown out, and are provided with fibrovascular bundles as in that case.

Ligule, and hairs on its edge.—The ligule is the small scale-like outgrowth on the ventral side, where the leaf-sheath and lamina unite—a constant feature of grass leaves. This varies a good deal in its shape and development in the different varieties of canes but lack of time has prevented its careful study thus far. Both its upper and lower margins are capable of considerable variations in outline and, in general, it frequently has a lozenge-shaped wider portion between extremely narrow wings. The edges are clothed with a delicate fringe of setæ, and these again vary a good deal. They are usually small and closely arranged, but in *Sonabile* they are long and ciliate, while in the *Kahu* group they are poorly developed and frequently disappear early.

10. LAMINA.

This part of the cane has at present been incompletely studied and several characters, since noted, have not been noted in the Punjab canes. The leaves of the North Indian canes dry up quickly towards the end of the season. Those at Aligarh hardly had a trace of green in them in January because of the dryness of this region, while those at Gurdaspur were yellow or straw coloured at the same time because of frost. As it was found impossible to make comparative observations on the foliage at this time of year, a special visit was paid to North India during the last rainy season and the characters here detailed are the result of that visit.

Width and length, average extremes, and proportion of these to one another.—The width of the leaf in any variety or in any shoot of any variety is not constant. Well grown specimens will have a vastly different width of leaves from that in a meagre half starved plant. And in the same bush the leaves vary a good deal according to age, the period of growth and the activity of growth at any time. This renders the comparison of the width of leaves difficult and I have merely taken what appeared to me the general width and added to it the maximum observed. The same remarks apply to the length of the lamina, except that this has been carefully measured in six shoots, to determine the form of curve presented by the increasing length of leaves from the base, and also to see if any relation could be traced between length of leaf and of sheath and thickness of joint. The figures taken have not yet been studied in these directions and are probably too few for any deductions to be made. Besides this, there was great difficulty in measuring the length of the lamina because the tips were so frequently injured and the lower leaves broken off, and numerous approximations had to be made. For these and other reasons, I have elected to take the extreme length and width for each case and, by dividing the former by the latter, have tried to get an index for the leaf, in exactly the same way as was done for the stem. A reference to the

figures will show that the leaves of the Punjab canes are as a rule very narrow, rarely much exceeding one inch, and in *Katha*, as might be expected, falling a good deal short of this. *Kahu* stands out with a width of over 2 inches, a representative of the broader-leaved *Ganna* canes. The index figures range from 59 for *Katha* to 23 for *Kahu*, chiefly due to differences in width, as there is no very great variation in the length of the leaf in the Punjab varieties.

Channelling, etc.—This refers to the way in which the base of the lamina is folded. In *Katha* it forms a well defined channel at the base, and this is constantly less evident as we proceed to the thicker canes. In *Saccharum spontaneum* the channelling is a marked character. Under this heading might be included the character of the leaf edges, they being sometimes straight, sometimes wavy, or indeed twisted at the base. The vestiture has not been studied in these canes but there are many points in it worthy of note. This may be referred to in later descriptions.

Colour and transverse marks.—Here, again, observations are incomplete. The colour of the leaf is often an index to the health of the plant, deep green being the sign of abundant nitrogenous assimilation. But there are also varietal differences. For instance, the leaves of *Katha* are more or less grey green or glaucous green and rather dark, whereas those of *Dhaulu* are of a much fresher green with less bloom. The transverse marks are seen dorsally at the base of the lamina on each side of the midrib. The lamina at this place is not infrequently bloomed and more or less devoid of the green colour of the leaf elsewhere. Sometimes there are patches of colour, purples, browns, pinks predominating, but the North Indian canes do not show many of these more striking colorations and have not attracted much attention as a consequence.

Serrature of the edge of the leaf.—As is only too well known, the edge of the cane leaf is provided with a series of close-set, silicious spines, all facing one way and capable of acting like an exceedingly sharp saw and causing severe cuts on the face and hands. An

attempt was made to study this feature, but the work came to a practical standstill by the discovery that, in any one leaf, the form and arrangement of the spines varies with the part of the leaf in which the observation was made. It has now been decided to examine the hairs at the middle of the leaf only. Care must be taken to select a leaf from which the spines have not been broken, as they are sometimes very fragile and the youngest unfolded leaf is often found to be most suitable. If still younger leaves are taken the hairs are undeveloped. There is no doubt that the harshness and persistence of the spiny hairs on the edges of the leaves of canes vary a great deal in the different varieties, and the matter will be worked at until some useful method can be evolved of putting these differences down.

Proportional width of lamina and midrib.—This has at present been incompletely studied. It is evident that narrow-leaved canes such as *Katha* differ very widely from the others in the relative width of the midrib and the lamina, and the North Indian canes as a whole differ almost as much from the thick tropical canes met with further south. The plan adopted has been to take the proportional width of midrib to that of the whole lamina, at the base, and at distances of one inch, 6 inches, 12 inches and at the widest part of the lamina wherever that may be. These observations have hardly been commenced, and it is proper to state that the measurements of foliage of the sugarcane generally are only here mentioned in order to indicate the lines on which it is proposed to work.

For convenient reference, a summary of the measurements of the varieties dealt with in this paper is appended (Table I).

TABLE I.—*Summary of Measurements of Punjab Canes.*

No. of dead leaves.	Length of canes after strip-piling these.	Total length of canes at 6 months.	Total length of canes at 10 months.	No. of joints at 6 months.	No. of joints at 10 months.	No. of few-jointed canes in 20 canes at 10 months.	Average length of mature joints at 10 months.	Index of cane. Length divided by thickness of middle joints at 10 months.	Average length of joints at 10 months.	No. of joints under 2" long at apex—6 months.	No. of joints under 2" long at apex—10 months.	Average greatest length of leaf-sheath.	Proportion of lamina to sheath (100) at junction.	Average extreme length of lamina.	Extreme width of lamina.				
Katha ..	..	14 4'1"	5'6"	57" 62"	22 23	7	3'7" 0'40	1'56	2'0"	5'3"	3	6	11'3"	71	3'11"	0'8"	59	33
Lalri ..	..	12 3'3"	4'1"	52" 50"	19 17	10	3'3" 0'55	91	1'6"	4'6"	3	5	11'7"	78	4'4"	1'05"	50	20
Kansar ..	..	7 2'7"	7'9"	64" 65"	18 20	10	4'5" 0'59	109	2'5"	6'0"	4	6	12'8"	72	4'4"	1'13"	40	..
Dhulni of Gu'daspur	14 4'9"	5'9"	73"	69"	25	27	6'	?	3'1"	0'49	142	5	7	10'9"	82	4'0"	1'30"	37	18
Foreru of Gurdaspur	13 3'3"	6'7"	66"	71"	24	24	12'	?	3'7"	0'45	150	4	6	10'2"	..	3'9"	1'20"	37	..
Dhulni of Phialaur ..	..	..	..	..	59"	..	..	..	3'6"	0'61	97	8	..	..	..	..	..	..
Kanara	10 2'4"	6'3"	50"	54"	21	25	4	2'6"	0'61	85	3	7	12'0"	76	3'10"	1'0"	46	..
u'Ka'u	10 2'4"	6'4"	47"	57"	18	21	10	3'7"	0'77	74	4	6	10'3"	84	4'2"	2'2"	23	14

NOTE ON THE LENGTH OF JOINT IN DIFFERENT PARTS OF THE
SUGARCANE.

The measurements of length of joint given in this paper are averages, in each variety, of six canes six months old and twenty ten months old. They were taken from the same plots at Gurdaspur Farm in September and January, with the solitary exception of *Dhaulu* where they were taken from different plots. It is unfortunate that only six canes were measured in the first period, but this was due to the fact that the real work of that visit was the study of foliage characters and more than six canes could not be dealt with in the time at disposal. The number of canes necessary for a proper average of each quantitative character has not as yet been determined. While it is certain that six are not enough for relative length of joints, it is hoped that twenty may be ample, because the labour, as explained above, is excessive, not only in taking the measurements and tabulating them but in working out the averages.¹

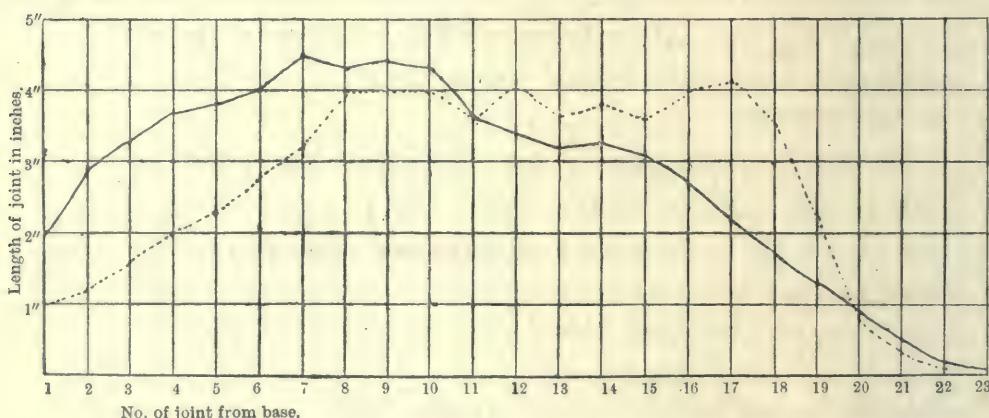
Curves were prepared of the averages of the lengths of the joints in different parts of the canes. But to prepare proper averages turned out to be a very difficult and puzzling matter. The following plan was ultimately adopted. The average number of joints was obtained and this formed the basis for each variety. Then the average lengths were taken of the joints, commencing with the lowest, and proceeding upwards until it became evident that some of the joints of the shorter canes were no longer mature. Then the reverse process was adopted and the lengths were averaged, commencing at the top joint, one-tenth of an inch long, and working downwards to the mature joints. The actual junction of these two curves in the middle was made a matter of compromise after studying the whole series, but care was taken to make the curve as uniform as possible at the point of junction. There are obvious

¹ It was not possible to commence the measurements at the very base of each shoot, but each cane was cut at ground level. There was no earthing up of the canes in the field.

objections to this method,¹ but I would refer to the two series of figures given below for *Lalri* canes (2) and (15) which had 16 and 25 joints respectively. A little study of these series will show that there are very considerable difficulties in the way of obtaining an average.

Partly owing to these difficulties, the curves were very carefully worked out in different ways, and, at the time, it occurred to me that they might be published. But the insufficient number of measurements taken at six months made this inadvisable. In, however, comparing the two series it took very little time to note that all the varieties agreed in presenting some very curious anomalies. I have chosen the *Katha* curves to illustrate these.

Length of joint in Katha.



It is seen that the six months cane starts with an average length of joint of 1", while the ten months cane starts with a 2" joint. The curve is therefore higher from the start for the ten months canes; this continues markedly for the first eight joints, when the two curves run more or less parallel; at the eleventh joint the six months curve passes upwards, crosses the other curve and continues above it until the 20th joint when, with a very

¹ Reference is invited to Table II. The plan adopted involves repeating some of the middle joints of the canes of Series (I) and omitting some of the middle joints in Series (II). This has the effect of steepening the curves of Series (II) and flattening those of Series (I), both of which results are desirable.

quick descent, it again crosses the ten months curve and finishes. The latter parts of the two curves differ in that the ten months curve descends in a much more gradual manner. Similarly related curves were obtained in all the varieties examined, except *Dhaulu*, but in this case the two sets of canes came from different plots and the results are not fairly comparable.

In comparing the curves of these two periods of growth, there are three points which require explanation. (1) The terminal joints decrease in length much more slowly in the ten months canes, (2) there are comparatively few joints added during the period between September and January, and (3) the basal joints are considerably longer in the older canes and the maximum length is much more quickly reached.

The first point is, I think, easily explained, in that the six months canes were growing rapidly, and their end joints showed this in marked differences in length. On the other hand, growth had ceased in the ten months canes and the joints formed at this period remain practically stationary. Such leaves as are formed towards this period remain small and stunted, and are frequently dried up by frost. The figures for the other varieties can be obtained from the Table of measurements preceding. In this table the numbers of joints at the ends, under two inches in length, are given for each variety at six and ten months, and exactly the same phenomenon is to be noted in each case.

The explanation of the second point is, at first sight, easy enough, on the assumption that few joints are added after September. But a study of the figures more carefully shows that many terminal joints in the older canes must be considered new, or we have the curious anomaly that the terminal joints actually decrease in length with age. A similar difficulty is experienced when trying to explain the third point, for if the curves are comparable, it is obvious that the basal joints increase in length throughout the plant's growth. Such an increase is, however, hardly possible, when one considers the mode of growth and maturing of the joints

of the cane, the hardness of the rind and the deposition of waxy and silicious incrustations.

There are thus obvious discrepancies between the two curves. Let us take the case of *Lalri*, where the following are the average lengths in inches of successive joints in the six and ten months canes :—

- (a) six months, 1·6, 2·0, 2·5, 2·9, 3·3, 3·7, 3·7, 3·9, 3·9, 4·0, 4·2, 3·7, 3·3, 3·3, 3·2, 2·0, 0·7, 0·4, 0·1 (18·6 joints).
- (b) ten months, 2·9, 3·7, 4·0, 4·4, 4·3, 4·5, 4·7, 4·1, 4·0, 3·9, 3·1, 2·2, 1·5, 1·0, 0·6, 0·3, 0·1 (17·2 joints).

Here, as in *Katha*, the basal joints are longer in the ten months canes, and the maximum is more quickly reached, there are five terminal joints under two inches in length in the ten months canes and only three in the six months canes, while there are even fewer joints in the older canes than in the younger. An examination of the full set of measurements at ten months brings out the fact that the canes vary a good deal among themselves as regards the length of the joints in different parts. The extremes may be exemplified by the following :—

Lalri, Cane No. 2.—4·5, 4·9, 4·9, 5·0, 4·3, 5·1, 4·8, 3·4, 2·9, 2·4, 1·2, 1·1, 0·9, 0·6, 0·2, 0·1 (16 joints).

Lalri, Cane No. 15.—0·9, 1·0, 1·0, 0·9, 1·0, 1·5, 1·7, 2·1, 2·7, 3·2, 3·4, 3·7, 4·3, 4·0, 4·6, 4·5, 3·2, 3·7, 3·3, 2·4, 1·6, 1·2, 0·7, 0·5, 0·1 (25 joints).

And a further study of the whole series shows that the canes measured can be divided into two, practically equal sets, one set with canes more or less similar to Cane No. 2 and the other approximating to Cane No. 15. I have chosen *Kahu* for the full demonstration of this peculiarity, and reproduce the full set of measurements of the lengths of the joints at ten months (Table II). The 20 canes have, however, been separated into two series, the first commencing with long joints and quickly attaining the maximum, usually also with fewer joints as in Cane No. 2 of *Lalri*, and the second commencing with short joints and slowly attaining the

maximum and usually with many joints as in Cane No. 15 of *Lalri*. One of the *Kahu* canes, No. 6, is abnormal in that it combines, so to speak superposed, the characters of the two series, and accordingly has two maxima. Because of the longer basal joints, I have included it in Series I, although its proper place should undoubtedly have been between the two series.

These two series exhibit in an exaggerated form the differences, noted above, between the earlier joints of the six months and ten months canes (shown in the *Katha* curves). Now a study of the measurements of the whole of the six months canes shows that they usually belong to the second series, the lower joints being moderately short and gradually increasing in length up the stem. The canes of the first series are practically absent in the six months crop and the suggestion is natural that the canes of this series are unrepresented there or very slightly so, are, in fact, new formations, late-formed canes which had not reached sufficient size to be measured as mature canes in September.

TABLE II.—LENGTHS OF JOINTS (IN INCHES) OF 20 KAHU CANES, 10 MONTHS OLD.

SERIES I.—Canes with few joints long at base.

SERIES II.—Canes with many joints short at base.

* Abnormal cane, with two maxima, whose correct place would be between the two series.

If this interpretation is correct the discrepancies in the six and ten months curves disappear. The longer basal joints in the ten months curve are due to the inclusion of a large number of late-formed shoots with this character, and the comparatively small increase in the number of joints in the ten months canes is due to these late-formed canes having comparatively few joints. It has been noted in the field that the canes in September are nearly, if not quite, as high, on the average, as in January, and this can also be explained by the inclusion in January of a large number of late-formed canes which are shorter than the others. There are, on the other hand, probably a considerably larger number of mature canes in each clump, and therefore a heavier crop.

It is quite possible that the relative proportion of these late-formed canes will be found to differ in the various kinds of cane grown. In fact, there are some indications that this is the case. From an examination of the individual measurements taken at ten months we find that *Lalri*, *Kansar*, and *Kahu*, the three thickest canes, have, each of them, ten few-jointed canes with long basal joints out of the twenty. *Dhaulu* of *Gurdaspur* has six (?), *Katha* seven and *Kanara* four. This seems to indicate a different mode of growth in the three first varieties, apparently in the direction of a less rapid early development, which may turn out to be of diagnostic as well as of agricultural value. No data are available as to the chemical properties of the two series of canes, but it would be worth while to make some observations on the point. With regard to their other characteristics, *Lalri* and *Kahu* have been selected and the results of an analysis are shown in the table appended.

TABLE III.

Summary of characters of the two kinds of canes in Kahu and Lalri ten months crops.

	Number of joints in the cane.	Total length of cane.	Av. length of mature joint.	Av. length of shortest (basal) joint.	Av. length of longest joint.	Number of top joints under 2" long.	Thickness of mature joint in decimals of an inch (lateral + medial).			Length of cane divided by thickness at middle.
							Base.	Middle.	Top.	
Kahu.										
Whole 20 canes	21.5	57.3"	3.4"	2.7"	4.7"	6	75+76	75+78	72+76	74
Series (I) 10 canes ..	19.0	54.7"	3.8"	3.4"	4.9"	6	72+73	71+74	67+71	72
Series (II) 10 canes ..	23.0	59.7"	3.2"	1.9"	4.4"	6	77+78	80+83	76+89	76
Lalri.										
Whole 20 canes	17.2	50.0"	3.9"	2.9"	5.2"	5	51+54	54+56	54+56	91
Series (I) 10 canes ..	15.1	46.4"	4.3"	3.7"	5.6"	5	50+52	52+55	52+56	87
Series (II) 10 canes ..	19.5	53.7"	2.7"	2.3"	4.7"	5	53+56	55+58	55+56	95

These figures are very remarkable in their uniformity, those for the whole series of 20 being in every case the mean between those of Series (I) and Series (II). From a careful study of the table it appears that the canes of Series (I) have fewer joints, but longer ones, especially at the base, and are thinner and shorter canes. They have thus considerably less cubical content, and the variety with a larger proportion of them will presumably produce a smaller crop, other things being equal. We have seen reason for assuming that they are late-formed shoots. But it is seen that they are thin and therefore have nothing to do with "water-shoots" or "gourmandisers"—those thick, long-jointed late-formed shoots, so typical of certain varieties and conditions. These water-shoots are characterised by enormous thickness, extremely rapid growth, much water and little or no sugar content, so that they are valueless from the crop point of view.

Botanically, the peculiar mode of growth of the late-formed shoots is not difficult to understand. The shoots first formed in the cane appear at a time when the plant is small, with limited foliage and root mass. Their joints are, naturally, short at first and only gradually increase in length up the stem, for the growing power is limited. A greater production of leaves and roots is desirable and these can only arise at the nodes and, the shorter the joints, the more nodes are available. Later on, when there is full vigour of growth, with a dense mass of leaves and a great root system, the new shoots will grow more rapidly, fewer leaves and roots are needed and the joints will consequently be longer. From another point of view, the *thinness* of these late-formed canes is of interest, for thinness combined with elongation of joints is a character usually exhibited by shoots or plants growing in the shade. The late-formed shoots, heavily overshadowed by the mass of cane leaves above them, will naturally strive upwards after the light. In all probability, these two factors, of more powerful growth and striving after light, both have their influence in determining the mode of growth of the later formed cane shoots.

KATHA.

1. GENERAL REMARKS AS TO DISTRIBUTION AND AGRICULTURAL AND CHEMICAL CHARACTERS.

A. The most universally grown of any variety in the Province. It is found (1) extensively grown under *barani* (rainfed) conditions in submontane tracts, where the rainfall, although moderate, is insufficient for other kinds,

(2) under well and canal irrigation in submontane tracts slightly further removed from the hills,

(3) in low lands along river and canal banks and on the borders of swamps, where the absence of drainage prevents other varieties from growing. In these localities *rab* is generally made, as the crop never properly ripens,

(4) in the Canal Colonies in the southern districts of the Province, as it withstands the hot, dry climate better, than the other varieties.

A thin, reddish cane, very hardy and with great tillering powers, capable of withstanding considerable drought, flooding and, to a less extent, frost. *Katha*, sometimes called *Chan*, ripens earlier than any other variety. The leaves are very persistent and it is consequently a difficult cane to strip. The rind is hard and the cane is therefore not used for chewing. The juice is not of a good colour but is much liked for drinking. It is said to be more wholesome than that of *Dhaulu* as the latter, although of a nice, white colour, produces an excess of saliva after drinking. The juice is small in quantity compared with the other varieties but contains a good percentage of sugar. The *gur* is said to keep better than that of the other local canes. It is said to have arisen from the wild *Kahi* grass which grows in swampy lands of the submontane

tracts. A good crop yields 30 maunds of gur per acre. (The rind of this variety is much valued for its strength and, when crushed in the wooden *belna* mill, is used extensively for mats, cordage for mhotes, etc., especially around Jullunder. The word *Katha* means red. Height at 6 months 7-8 feet; at 10 months 8-9 feet at the Gurdaspur Farm. Erect, in bunches, often falling where irrigated. Sometimes tied in cocks or otherwise supported. The older leaves stand out rather markedly from the stem and are widely separated. The variety is a good deal attacked by smut and an agaric (*Fomes lucidus* according to Dr. Butler) was found growing rather profusely in some parts of the field at harvest. Rooting was seen on the lowest four joints and shooting was not a marked character in the field. C. A. B.).

B. A hardy cane yielding *shakkar* on good soil. The variety is classified as frost-resistant on the results of the last three years experiments. The average composition of the juice (average of the last three years) is :—

Month.			Sucrose %	Invert sugar %
November	..	..	12·75	2·80
December	..	..	15·39	1·23
January	..	..	15·46	1·51
February	..	..	16·48	0·80

It is fully ripe about the beginning of February. The *gur* or *shakkar* made from various specimens of the variety yielded a sucrose content from 56·72 to 73·64 per cent.

(The details of sections A and B have been kindly provided by Messrs. Southern and Barnes respectively).

2. LIST OF SPECIMENS EXAMINED.

Young canes, 6 months old.

(a) Gurdaspur, September 1913. Irrigated, on the farm lands; 18 canes examined, the foliage measured and drawn, and the crop photographed.

(c) Lyallpur, September 1913. Irrigated farm crop. The field photographed for habit. It is to be noted that the leaves were remarkably narrow.

Mature canes, 10 months old and ready for reaping.

(b) Gurdaspur, January 1914. The same irrigated farm plot ; 25 canes examined of which 20 were measured. Canes drawn, painted and photographed to scale ; field photographed.

Canes about 12 months old.

(d) Jullunder, 10th March 1913. Irrigated ryot's field, being milled in the "Belna" ; 6 canes examined, drawn and photographed to scale.

(e) Gurdaspur, 13th March 1913. Rainfed canes from neighbouring villages ; 6 canes examined, photographed to scale.

(f) Harchowal, 15th March 1913. Ryot's field ; 6 canes examined and photographed to scale.

3. GENERAL CHARACTERS OF THE VARIETY.

The *Katha* cane is thin, straight-sided and without prominent nodes. It is glaucous green to brown yellow at six months but turns brown or vinous towards crop time. There are characteristic red brown marks in the groove and it is affected by smut. Ivory markings are present but not abundant, usually in the upper part of the joint and often passing through the bloom band. The growth ring is distinct, becoming dark brown in old joints. The circlet of hairs is more or less persistent all the way up and there is usually a distinct scar band. The buds are moderately small, rounded and bursting more or less dorsally. They reach the growth ring and are not very well provided with hairs ; minute black hairs are not usual on them. The leaves stand out well from the stem and are narrow and grass-like ; the young leaves are sharply bent at the tips, but soon become broadly curved. The lamina is distinctly channelled at the base and the midrib comparatively wide there.

The leaf-sheath is glabrous, embraces the shoot broadly and has light coloured edges. Ligular processes are well developed, although they may be very long or almost absent in leaves of the same shoot.

4. CANE MEASUREMENTS.

Dead leaves at six months old.—The six months old canes had on an average 13-14 dead leaves, none of which had fallen from the stem. These canes were in full vigour, with good leafy shoots. It was found that the canes at crop time did not offer any chance of examining the foliage characters, and this was the reason for the special study of the six months canes. The leaves of the older canes were mostly dead, although still clinging to the stem and a small tuft of yellowish or brown leaves was left at the top, quite unfit for general study. This applies to all the varieties.

Length of six months canes after stripping dead leaves.—The canes averaged 4' 1" and the shoots 5' 5" long.

Total length of cane and number of joints at six and ten months.

- (a) 6 months old canes 57·2", including 21·6 joints.
- (b) 10 months old canes 62·4", with 22·6 joints.

Total length of stripped cane divided by average thickness at the middle,

$$l \div t.$$

- (a) 129, (b) 156.

From these figures it will be seen that the growth of the cane after the end of September is not very great.

Length of joints in different parts of the cane in inches.

- (a) average of 6 canes : 1·0, 1·2, 1·6, 2·0, 2·3, 2·8, 3·2, 4·0, 4·0, 3·6, 4·1, 3·6, 3·8, 3·6, 4·0, 4·1, 3·5, 2·2, 0·8 0·3, 0·1.
- (b) average of 20 canes : 2·0, 2·9, 3·3, 3·7, 3·8, 4·0, 4·5, 4·3, 4·4, 4·3, 3·6, 3·4, 3·2, 3·3, 3·1, 2·7, 2·2, 1·7, 1·3, 0·9, 0·5, 0·2, 0·1.

An examination of these figures shows that the lower joints of the older canes are generally longer than those of the

younger canes, suggesting that growth in length takes place at the base of the cane. There is, however, another explanation which has already been given in a special note. It is also evident that the terminal joints of the younger canes decrease much more quickly in length than in the older ; this is taken as showing that growth has largely ceased at this part of the cane.

Thickness of the cane at various points.—One of the characters of *Katha* is that the joints are of fairly uniform thickness all the way up. Measurements were taken in the 10 months old canes at the base, in the middle and at the uppermost mature joint, as follows :—Base 0·40", middle 0·39", top 0·41", differences quite within the range of personal error.

5. COLOUR OF CANE.

As already mentioned, the six months old canes of *Katha* are glaucous green to brown yellow. There is hardly a trace of the rich brown colouring which later forms so marked a character of the cane. The ten months canes are apple green in the young, covered joints of the shoot, becoming glaucous green or yellow with pinkish dots and patches lower down. But when fully formed, besides greens and yellows, the joints show a prevailing violet or vinous brown which is very striking. This colour is caused by a rich brown skin under the bloom and, where the bloom is rubbed off, the cane often shows a fine brown colour.

The Bloom band is distinct at the top of the cane but becomes dulled lower down. Bloom descends over the joint, changing the green colour of young joints to glaucous green and the dark brown skin of older parts to pinkish brown or violet.

The root zone in the young canes is covered with bloom and cream coloured in the younger joints, becoming bone yellow.

The growth ring is green in the younger joints but soon becomes brownish. Later on the brown deepens, often first at the upper and lower edges of the ring, until it is a rich dark brown. The growth ring has no bloom, and its colour in old joints is similar to that of the skin beneath the bloom layer.

Blushing of the stem on exposure does not appear to be common in *Katha*, but young canes take on a faint pink colour when cut, and older ones become more or less red in time.

Blackening is not marked but is occasionally seen in old canes.

The Groove has black incrustations of small rounded bodies and red brown marks made up of fine, parallel lines.

Ivory markings are usually present but not in great quantity, being chiefly confined to the upper parts of joints and sometimes passing through the bloom band. They are seen not infrequently to change to splits and are present in the older root zones. In the young, upper parts of mature canes, the markings become more abundant and here take on the character of those in *Dhaulu*, long close parallel lines in the middle or upper third of the joint. Most canes seem to have one young joint marked in this curious way.

Splitting is not infrequently met with and these splits obviously arise from the ivory markings in most cases. There is a *scar band* rather than a *scar line* in *Katha*.

6. CHARACTER OF THE JOINT.

Thickness, ovalness in section.—*Katha* is the thinnest cane in the Punjab and perhaps in India. Quite a number of specimens of *Saccharum spontaneum* have been met with which were thicker. But it is to be noted that the canes at Gurdaspur appear to be rather thinner than usual, and I am told that *Katha* becomes much thicker eastward around Jullunder and Ludhiana. The following measurements were taken in the middle of the canes examined :—

- (a) of 18 canes six months old, average 0·48".
- (b) of 20 canes ten months old, average 0·40" ($0\cdot35" + 0\cdot47"$).
- (d) of 6 canes, thickest 0·51", thinnest 0·42".
- (e) of 6 canes, thickest 0·44", thinnest 0·34".
- (f) of 6 canes, thickest 0·45", thinnest 0·35".

The canes in *Katha* are seen to be well under half an inch in diameter.

As regards *ovalness*, they are remarkably cylindrical, the ovalness found in all canes being very slightly developed as is seen below, lateral + medial :—

- (b) Bottom of cane $0\cdot40'' + 0\cdot42''$.
Middle of cane $0\cdot40'' + 0\cdot41''$.
Top mature joint $0\cdot41'' + 0\cdot42''$.
- (d) Thickest cane $0\cdot51'' + 0\cdot54''$, thinnest cane $0\cdot42'' + 0\cdot43''$.
- (e) Thickest „ $0\cdot44'' + 0\cdot50''$, thinnest „ $0\cdot34'' + 0\cdot35''$.
- (f) Thickest „ $0\cdot45'' + 0\cdot47''$, thinnest „ $0\cdot35'' + 0\cdot37''$.

Length of mature joints (deducting top joints under 2 inches long)

- (a) of 6 canes the average mature joint was $3\cdot1''$, average longest $4\cdot5''$, average basal $1\cdot0''$.
- (b) of 20 canes the average mature joint was $3\cdot7''$, average longest $5\cdot3''$, average basal $1\cdot0''$.
- (d) The joints of 6 canes were judged to be from $3''$ to $6''$ long.
- (e) Do. do. $4''$ to $7''$ long.
- (f) Do. do. $4''$ to $7''$ long.

Shape viewed medially.—The joints are usually thickest at the leaf-scar, then at the junction of the root zone and growth ring or at the bloom band. The middle of the joint is slightly thinner, and the general shape is therefore biconcave. But the differences are so small that the joints may be described as practically straight-sided.

Shape viewed laterally.—The relative thicknesses of the different parts of the joint are as in the median view. But there is sometimes a slight tendency towards a bulge below behind, so commonly met with in other canes, and this gives a slight appearance of con-cavo-convexity.

The leaf-scar is practically horizontal and there is not usually a well marked lip under the bud. Sometimes however a distinct short lip has been noted. The end of the leaf-scar is not markedly decurrent.

The circlet of hairs is usually persistent right up the stem and is composed of short parallel hairs.

The groove varies a good deal, being present, indicated or entirely absent. When seen it is not usually deep, but rather a flattened region. The black incrustations and red brown marks have been referred to already.

The root zone is moderately narrow, not protruding, except sometimes in the lower, older joints. It has a distinct tendency to narrow downwards, making the growth ring look thicker than it really is. There are two or three rows of indistinct eyes, often tubercled when old, occasionally ivory markings cross the eyes in the older joints.

The growth ring is moderately broad and clearly marked with definite upper and lower boundaries. This ring is one of the most striking characters of the cane, and has been already described, as regards its colour.

7. BUD.

Shooting is not well developed in *Katha*.

Bursting is usually more or less dorsal, the apex of the bud being either in the middle or between the middle and the top.

The buds are small and flat, generally reaching the growth ring; rounded, almost circular, sometimes emarginate at the top because of the flanges.

They arise at the leaf-scar and there is no *cushion*.

The *flanges* arise about the middle and extend broadly round the apex. They are sometimes emarginate or truncated above and of a dark brown colour.

Bristles are usually sparse, but present round the upper margin; *basal patches* are better developed, sometimes of white parallel hairs and sometimes felt-like.

Minute black hairs are not characteristic and are often absent.

8. LEAFY SHOOT.

Colour, dark, slightly bluish green.

There are 5-6 leaves in the *terminal tuft* (borne on the top 2" of the visible shoot).

The *leaf ends* are erect at first, but soon become bent at a sharp angle. Later on they are broadly curved.

The *number of terminal joints under 2"* is three in the six months canes, and six in the ten months.

- (a) 2·2", 0·8", 0·3", 0·1".
- (b) 2·2", 1·7", 1·3", 0·9", 0·5", 0·2", 0·1".

9. LEAF SHEATH.

Length ; average longest.—Average of the six canes in inches :—
5·7, 7·3, 7·5, 7·7, 8·0, 8·2, 8·8, 9·2, 9·7, 10·3, 10·7, 11·2, 11·0, 10·8,
10·5, 10·2, 9·8, 10·0, 9·8, 9·9 (8·9, 5·9, 1·1, 0·2).

The longest sheaths were 10·7, 12, 12, 12, 10, 11·2, averaging 11·3.

Very slightly *bloomed*. Turning light clear brown when just dead in the six months canes, thus differing markedly from *Dhaulu* (q. v.). Not blushing red on exposure in the ten months canes, and here also differing from *Dhaulu*. The *scarious border* of the leaf-sheaths does not appear early, and the *edges* of the young sheaths are light coloured, and not red brown as in *Dhaulu*.

Glabrous, without spines; *hairs* between the veins behind minute, puberulous, hardly distinct under the lens.

Base of leaf-sheath *clasping* the stem rather widely, and passing one and a half times round the circumference.

Proportion of base of lamina to top of sheath 0·55 : 0·76.—In three other cases the proportions were 8 : 12, 8 : 12, and 7·5 : 11, thus leaving room for ligular processes.

Ligular processes short, tooth-like, or long and narrow, usually on one side only.

Ligule rather narrow, widening in the middle and with minute hairs on the edge.

10. LAMINA.

Width.—Very narrow, usually about 0·6", but occasionally reaching 0·8".

Length, average of 6 six months canes ;—2'0", 2'1", 2'2", 2'4", 2'5", 2'8", 2'10", 2'11", 3'2", 3'2", 3'6", 3'7", 3'9", 3'9", 3'9", 3'8", 3'8", 3'5", 3'6", 3'8", 3'9", 3'5", 2'11".

The longest laminas in the six canes were 3'9", 4'1", 4'1", 4'2", 3'6", 3'11", averaging 3'11".

Proportion of length to width 58·8 to 1.

Markedly channelled at the base.

Transverse marks yellowish green, becoming darker below; very slightly bloomed. *Serrature* strong, persistent.

Proportion of midrib to lamina at 1", 33 : 100, at 6", 27 : 100, at 12", 16 : 100.

DESCRIPTION OF PLATE.

KATHA.

1, Middle and 2, top of a ten months cane. The growth rings become darker brown as the joints mature; the circlets of hairs are distinct and persistent; in the middle of 2 there is one young joint with many ivory markings.

3. The upper part of a six months cane, showing the base of the sheath clasping the stem widely, and well marked ligular process.

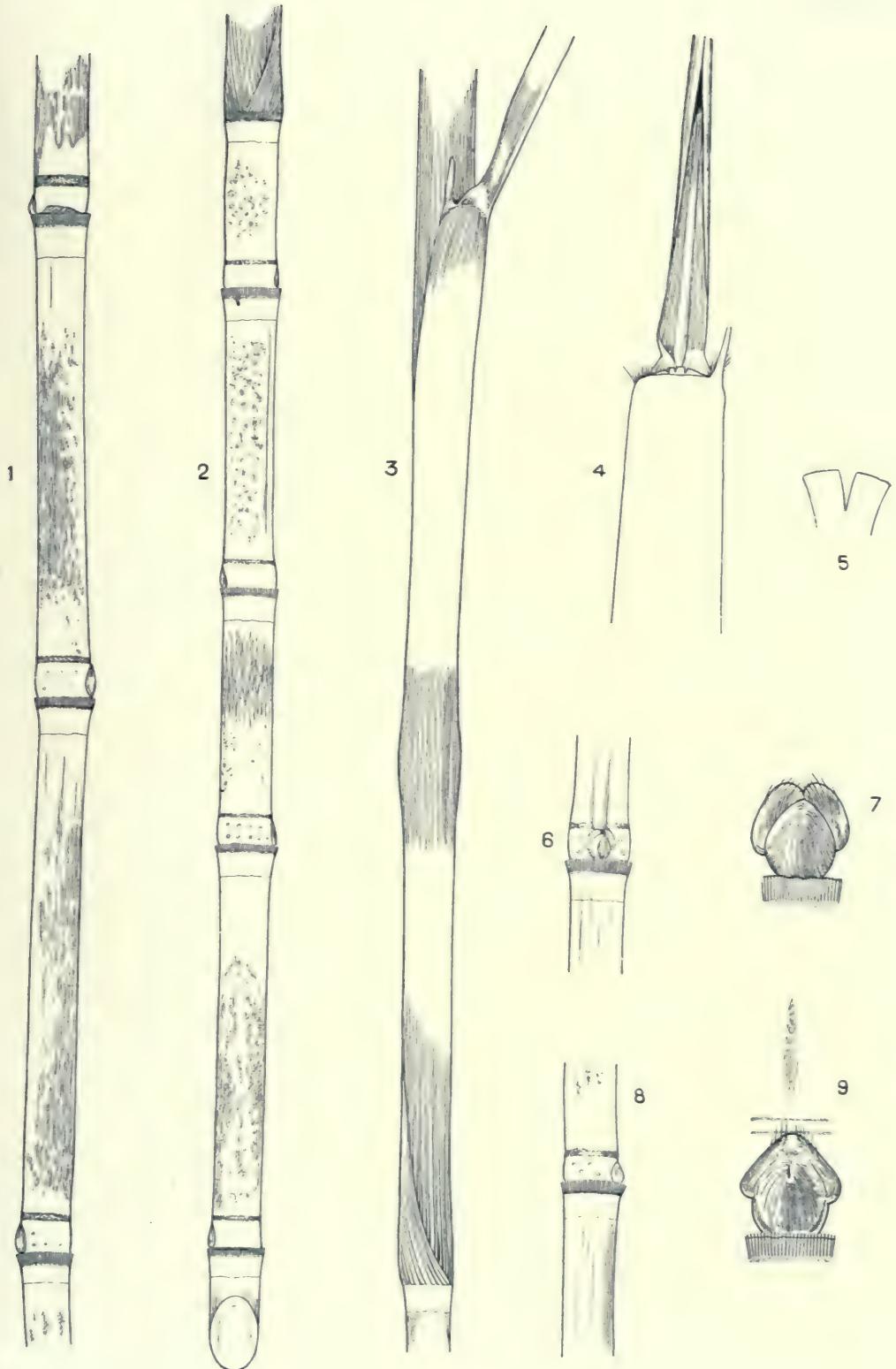
4. Lamina and sheath at the point of junction; the lamina is sharply infolded and there is a well marked ligular process on one side. The ligule is seen at the point of junction.

5. Part of the ligule with a fringe of minute hairs on its edge.

6. Node of a six months cane with circlet of hairs and small bud reaching the well marked growth ring. There is a distinct groove. The ivory markings cross the bloom band.

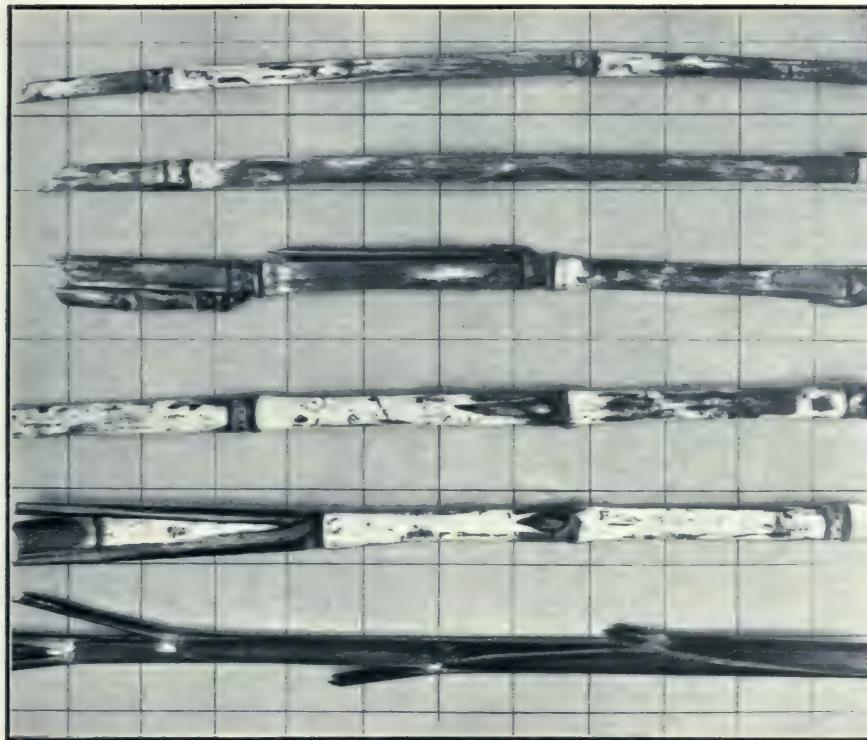
7. The bud of 6 enlarged, with few bristles and moderately distinct basal patches. The flanges are emarginate.

8, 9. Node of a ten months cane with its bud. The bud will burst dorsally and there is a distinct red brown mark in the groove made up of fine parallel lines.

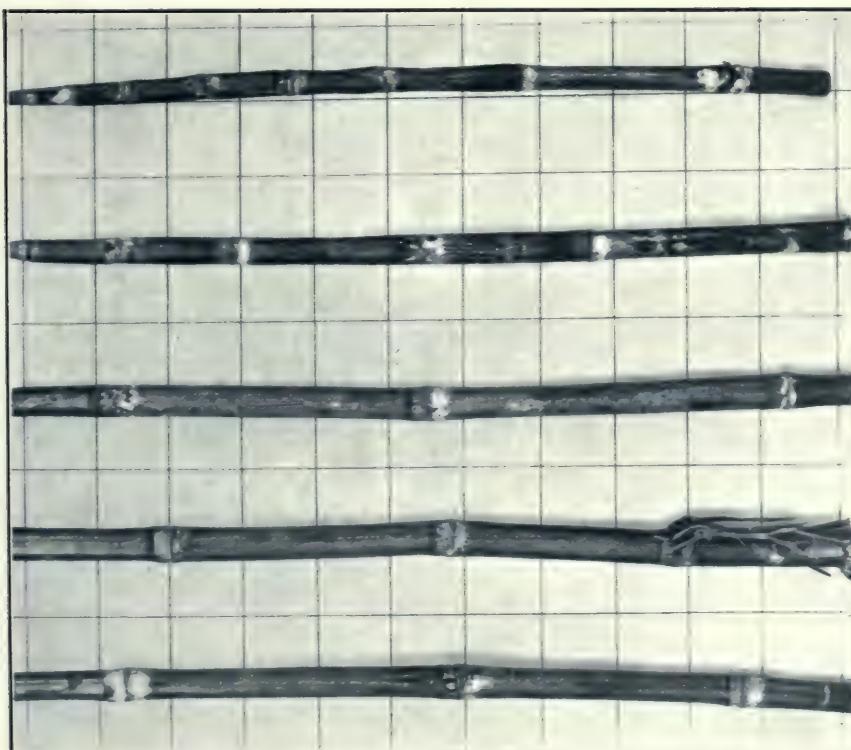


KATHA.

SACCHARUM SPONTANEUM.



KATHA.





KATHA, 6 months old, Gurdaspur.



KATHA, 6 months old, Lyallpur.

LALRI.

1. GENERAL REMARKS AS TO DISTRIBUTION AND AGRICULTURAL AND CHEMICAL CHARACTERS.

A. Extensively grown on well and canal irrigated land in the Karnal, Rohtak, and Delhi districts. The soil and climate of this tract are well suited to sugarcane cultivation and the yields are higher here than in any other part of the Province. *Lalri* is a cane of the *Katha* type, not unlike the *Chan* of Ambala but slightly thicker. It is said locally to be a degeneration from *Saretha*, but this is very doubtful. It is thinner than *Kansar*, matures later than *Katha*, but slightly earlier than *Dhaulu* of *Phillaur*. The latter cane and *Lalri* are extensively grown in the north of Karnal but here the *Dhaulu* ceases and *Lalri* takes its place further south. The yields of *Lalri* are very heavy, 50 maunds of *gur* being obtained from a good crop. (Height of the canes at Gurdaspur 8-9 feet at six months. Like *Katha* but taller and thicker and with broader leaves ; smaller and shorter than *Kansar* and the leaves spreading rather less ; some of the leaf tips soon broadly angled as in *Katha*. Tillering good, but the canes lodging with irrigation and with heavy crops. Suffering from smut. The six months canes were rooting for the first four joints and had about three shot buds each.—C. A. B.)

B. A hardy cane, yielding *gur* on good soils. The variety is classified as frost resistant on the results of the last two years' experiments. The average composition of the juice (average of the last two years) is :—

Month.		Sucrose %	Invert sugar %
November	..	11.56	2.34
December	..	12.56	0.84
January	..	14.31	0.70
February	..	16.21	0.45

It is fully ripe about the middle of February.

(For the details in these sections I am indebted to Messrs. Southern and Barnes.)

2. LIST OF SPECIMENS EXAMINED.

The canes of this variety were all from Gurdaspur Farm and include six months and ten months canes from the same plot. The former were, as usual, relied on for foliage characters, as these cannot be studied in ripe canes in the north.

Young Canes, six months old.

(a) Gurdaspur, September 1913. Irrigated farm plot ; 12 canes examined of which six were measured as to foliage and joints ; canes drawn and field photographed.

Mature Canes, ten months old.

(b) Gurdaspur, January 1914. Irrigated farm plot ; 25 canes examined of which 20 were measured as to length and thickness of joints. Canes drawn and painted and photographed to scale and field photographed.

3. GENERAL CHARACTERS OF THE VARIETY.

The *Lalri* canes examined were moderately thin, hard, straight-sided and without prominent nodes. They were evidently a *Katha* cane but thicker and shorter. The young canes were glaucous grey or white from excess of bloom ; later on the skin became brown under this bloom, and the cane vinous, the brown showing where the bloom was scraped off. The general colouring of *Lalri* was more vivid than in *Katha* or *Kansar*. The groove had occasional red brown marks as in *Katha*. Ivory markings short and few, usually in upper parts of the joints and occasionally passing through the bloom band. Growth ring very dark brown in lower joints of mature canes. Circlet of hairs persistent, strong, often brownish below, and sometimes changing to a felt or even disappearing higher up the stem. Scar band present. Buds small, rounded or pointed, usually bursting rather apically, but sometimes dorsally below ; usually reaching the growth ring except in some lower joints ; hairs not well developed, but minute black hairs present. Leaves as in *Katha* but broader, including the sharply bent tip in young leaves,

less channelled at the base and with proportionately narrow midrib. Leaf-sheath as in *Katha*; ligules distinct, tooth-like or long.

4. CANE MEASUREMENTS.

Dead leaves at six months old.

The average number of dead leaves in the six canes was 12.

Length of cane and of shoot after stripping these.

Average length of cane exposed 3' 3", of shoot 4' 1".

Total length of cane and number of joints at six and ten months.

- (a) Total length 51·8", number of joints 18·6.
- (b) Do. 50·0", do. 17·2.

Total length divided by average thickness at the middle, $l \div t$.

- (a) 92, (b) 91.

Length of joints in different parts of the cane, in inches :—

- (a) 1·6, 2·0, 2·5, 2·9, 3·3, 3·7, 3·7, 3·9, 3·9, 4·0, 4·2, 3·7, 3·3, 3·3, 3·2, 2·0, 0·7, 0·4, 0·1; 18·6 joints.
- (b) 2·9, 3·7, 4·0, 4·4, 4·3, 4·5, 4·7, 4·1, 4·0, 3·9, 3·1, 2·2, 1·5, 1·0, 0·6, 0·3, 0·1; 17·2 joints.

These figures are rather puzzling. In the first place there is something wrong in that there are more joints in the younger canes than in the older, although the material was drawn from the same plot. Secondly, the older canes apparently have longer joints at the base, suggesting a prolonged growth in this part of the plant such as is not justified by one's knowledge of anatomy. These facts have led to a more careful study of the columns of measurements, with the result that it has been demonstrated that there are two kinds of canes in the clump, longer, older, with shorter joints (especially at the base), and shorter, younger, with longer joints (especially at the base). And it has furthermore been shown that there are more of these younger canes in the older clumps. This subject has been fully dealt with in a separate note.

Thickness of the cane at various points.—This undergoes little change as we pass up the cane, *Lalri* being remarkably uniform in this respect.

- (a) Occasionally narrower at the base, but soon uniform upwards.
- (b) Average of 20 canes, base 0·51"; middle 0·54"; top 0·54".

5. COLOUR OF CANE.

The young canes are glaucous grey or white, green where the bloom is rubbed off, to yellow in the lower parts of the joints. In older canes the colour is, as in *Katha* and in *Kansar*, rather difficult to describe, but there is plenty of vinous colouring. On the whole, the red brown skin of *Lalri* is of a more vivid character than in the two allied forms, and is well seen where the bloom has been accidentally rubbed off, as well as in the blotches in the green, upper, younger parts of the cane. *Blackening* occurs here and there and is usually confined to the upper part of the joint. The *bloom*, as has been indicated above, is remarkably heavy, descending over the joint as a white layer, lightly over the root zone, but only dulling the growth ring. The *growth ring* is light brown in young canes, in older ones green in its upper joints and very dark brown in the lower ones. *Blushing* is not apparent in exposed parts. There is a well marked blackish grey *scar band*, between the bloom layer and the leaf scar. The ivory markings are few and short, usually confined to the upper part of the joint, occasionally passing through the bloom band. Here and there upper joints have massed markings as in *Dhawlu* and *Katha*. The *root zone* is sometimes marked by small brown slits. *Splits* are practically absent but sometimes arise from ivory markings. The *groove* has sometimes the red brown marks composed of fine parallel lines so characteristic of *Katha*.

6. CHARACTER OF THE JOINT.

Thickness, ovalness. *Lalri* is not such a thick cane as *Kansar*. The cane is remarkably cylindrical and ovalness is hardly perceptible as is seen from the following measurements, lateral + medial : —

- (b) Base 0·51" + 0·54"; middle 0·54" + 0·56"; top mature 0·54" + 0·56".

Length of mature joints.

- (a) average 3·3", average longest 4·6", average basal 1·6".
- (b) average 3·9", average longest 5·2", average basal 2·9".

Shape viewed medially.—Thickest at leaf-scar and root zone then at growth ring; hence, slightly biconvex; but practically straight-sided.

Shape viewed laterally.—Very slightly zig-zag; traces of swelling below behind, giving the joints occasionally a slight concavo-convexity.

Leaf scar practically horizontal, very occasionally slightly descending, and with a very short *lip*.

Circlet of hairs persistent, strong, brownish below. Occasionally present all the way up, but more often becoming a felt in the upper parts or even disappearing there.

Groove present, shallow, or absent; where present, seen all the way up the joint; occasionally showing the characteristic brown red marks of the *Katha* group.

Root zone usually slightly swollen or barrelled, especially in the lower joints; slightly bloomed; with moderately distinct eyes in two to three rows; sometimes with ivory markings, especially in the lower joints.

Growth ring distinct and not very broad in the specimens examined; its colour referred to above.

7. BUD.

Shooting noted on the average in the three lowest joints in the young canes. *Bursting* usually rather apical, but dorsal in some of the lower joints.

The buds small, rounded, or pointed, usually reaching the growth ring except in a few lower joints; if exceeding the growth ring, ovate triangular. Arising at the leaf-scar and without any trace of *cushion*.

Flanges not apparently well developed; *basal patches* present and sometimes regularly formed, white and glistening; *minute black hairs* present, especially below.

8. LEAFY SHOOT.

Five to six leaves in the *terminal tuft*. *Leaf ends* soon angled or bent as in *Katha*.

Number of terminal joints under 2", 3 in the six months canes and 5 in the ten months.

(a) 2·0", 0·7", 0·4", 0·1".

(b) 2·2", 1·5", 1·0", 0·6", 0·3", 0·1", showing the gradual cessation of rapid growth in the older canes.

9. LEAF-SHEATH.

Length, average longest.—The *average lengths* of the leaf-sheaths in the six canes of (a) were 7·2", 7·4", 7·7", 8·4", 9·0", 9·4", 9·8", 10·3", 10·8", 11·1", 11·1", 11·3", 11·1", 10·9", 10·6", 10·2", 10·2", (9·9", 9·6", 7·0", 1·8", 0·3", 0·1").

Average longest 11·7".

The sheaths do not fade to a crushed strawberry colour in the young shoots on dying nor are the edges red brown, as in *Dhaulu*; scarious border is not formed early; silicious spines are absent; the minute *hairs* between the veins behind are just visible with the lens, white above and black below.

Ligule narrow, broadening at middle, with minute hairs on the edge.

Ligular processes distinct, tooth-like in the lower parts but becoming longer in the terminal leaves of the young cane, on one side only.

Proportion of base of lamina to the top of sheath 12 : 17, 12 : 16·5, 14 : 18, showing room for the formation of the ligular process.

10. LAMINA.

Width 0·90"—1·05", averaging about 1 inch.

Length average of six canes measured (a) 2'1", 2'6", 2'7", 2'7", 2'9", 2'10", 3'1", 3'7", 3'7", 3'10", 3'9", 3'11", 4'0", 4'2", 4'3", 4'2", 4'1", 4'1", 4'0", 3'11", 3'8", 3'0", 2'3".

Average extreme length of leaf in these six canes 4'4".

Proportion of length to width 50:1.

Channelling moderate at base in cut leaves but not noticeable in the field; flattening out soon.

Transverse marks dull, yellow green, bloomed below.

Serrature rather soft and soon disappearing.

DESCRIPTION OF PLATE.

LALRI.

1, 2, 3. Lower, middle and upper portions of a ten months cane. The buds are small, not reaching the growth ring in the lowest joints but reaching or exceeding it higher up. The growth ring is faint in the upper joints but becomes darker below, often darkening at its upper and lower edges first. The circlet of hairs is persistent throughout. The lowest joint of 1 has ivory markings in the root zone.

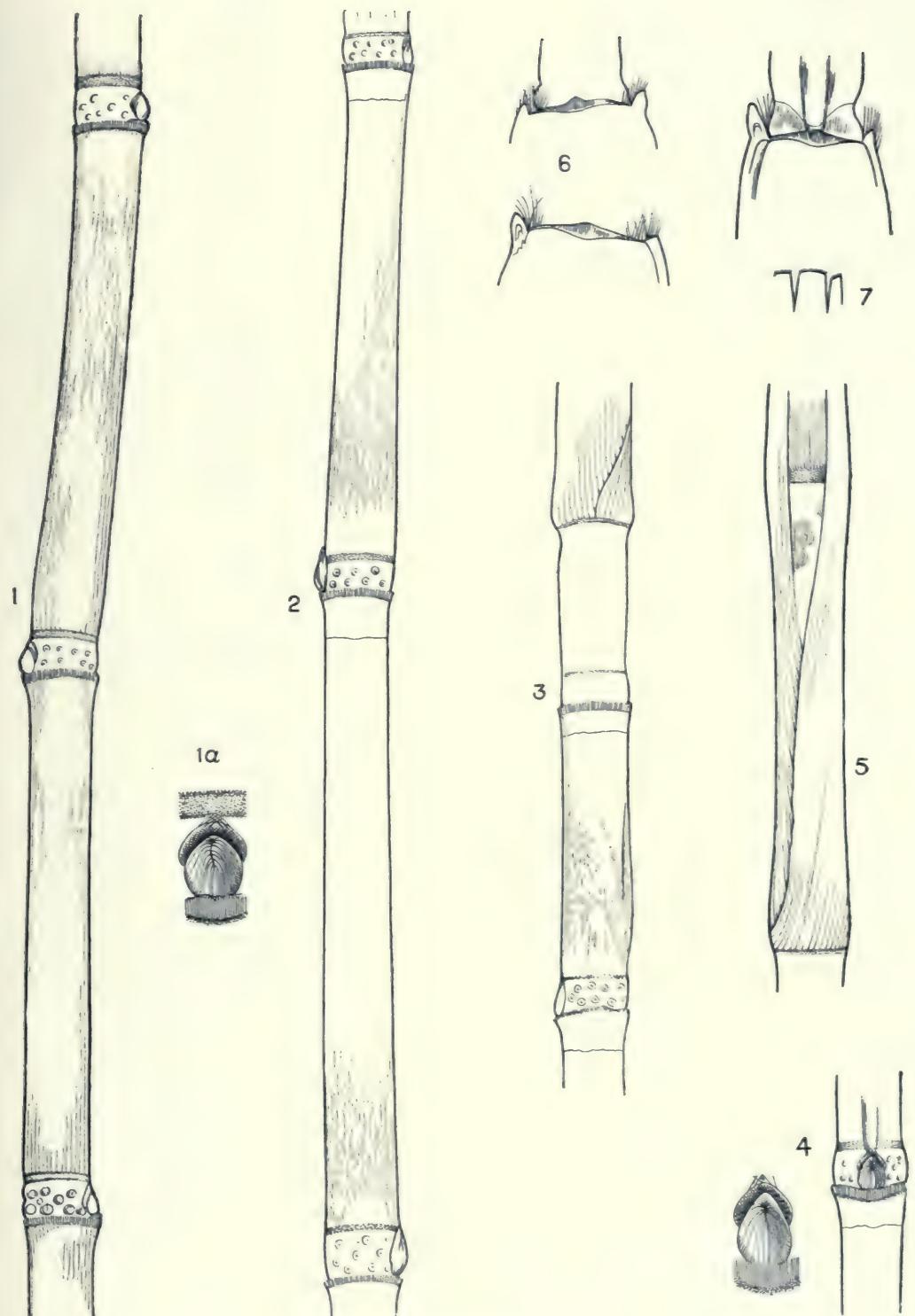
1a. The middle bud of 1. Bursting is dorsal; the flanges rise high up and pass broadly round the apex; bristles are few, but the basal patches are distinct.

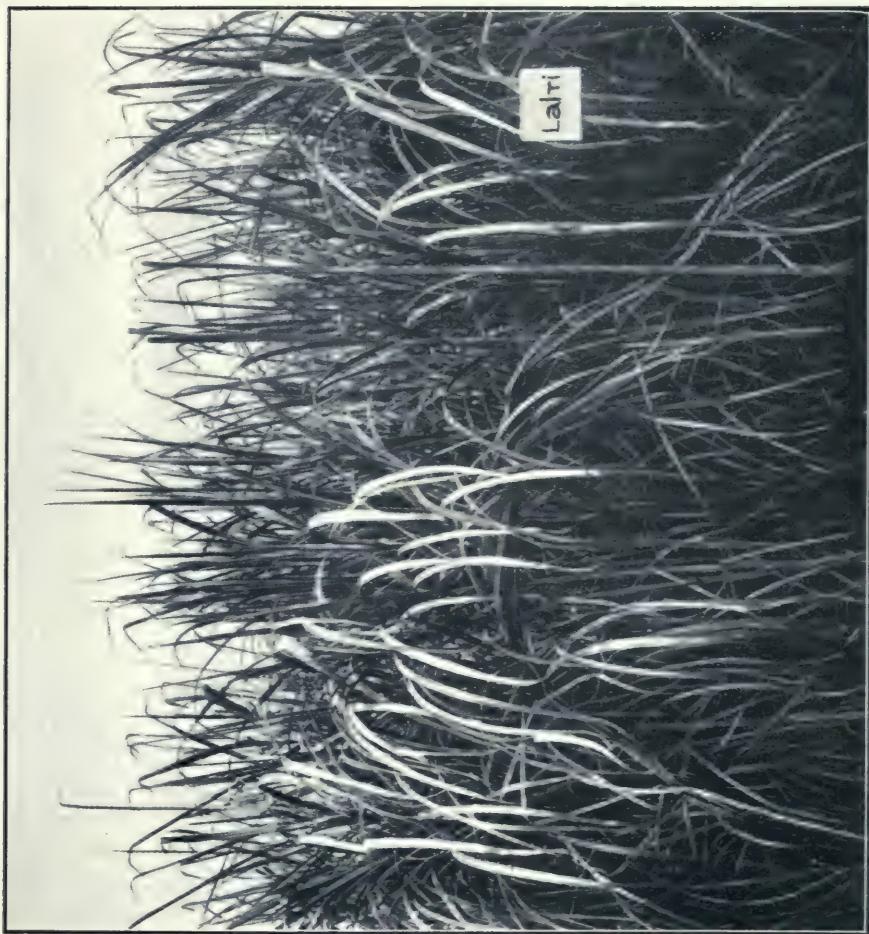
4. A lower node of a six months cane with its bud enlarged. There is a distinct groove. The bud is rather longer than in 1a but bursting is markedly dorsal. The scar band is rather broad and distinct.

5. Upper portion of a six months cane. The base of the leaf-sheath clasps the stem widely.

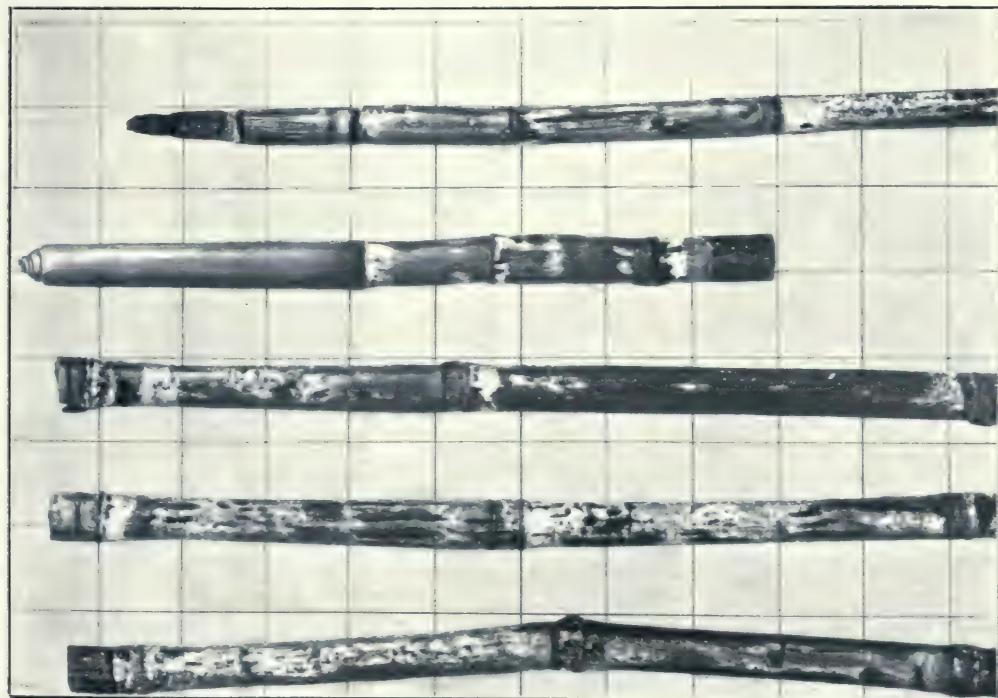
6. The junction of lamina and leaf-sheath in three leaves. Small ligular processes are present, sometimes on both sides.

7. A small portion of the ligule with minute hairs on its edges.





LALRI. GURDASPUR, 6 Months old.



LALRI.-Canes on inch squares.

KANSAR.

1. GENERAL REMARKS AS TO DISTRIBUTION AND AGRICULTURAL AND CHEMICAL CHARACTERS.

A. Kansar is most extensively grown in the submontane tracts, where the water supply and land are specially good. Large areas under this cane are found in canal irrigated land in the Batala Tehsil of the Gurdaspur district, where it is known as *Katha-Kahu*. It is also found in the submontane tehsils of Jullunder and Ludhiana where it is known by the names *Dag Chan* and *Masingen*. It has also been seen as far south as the Chenab Colony but this is exceptional. It dries up and becomes pithy in the centre unless the water supply is very good.

A tall growing, thick red cane of the *Katha* type, approaching *Saretha* in thickness. It requires good land and more abundant water than *Dhaulu* of Gurdaspur or *Phillaur*. It yields very heavily, a good crop giving 40 maunds of *gur* of excellent quality. (*Kansar* is a desi cane with broader leaf than *Dhaulu* of Gurdaspur ; the six months crop was 8-9 feet high. The leaf tips, at first erect, soon become angled as in *Katha*, then quickly curving backwards. The outer canes of a bunch bend outwards a good deal like *Saretha* ; tillering is good. Shooting was present in the six months crop on the farm, the shoots being green, tall, and straight ; rooting occurred to about the fourth joint. The crop on the farm was rather badly smutted.—C. A. B.)

B. A fine cane, not reckoned as hardy as *Lalri* or *Katha* ; yields *gur* on well-land. The variety is classified as semi-resistant to frost. The average composition of the juice (average of the last three years) is :—

	Month.			Sucrose %	Invert sugar %
November	14.05	2.71
December	14.95	1.48
January	14.44	1.35
February	14.77	1.32

It is an early ripening cane and is fully ripe about the end of December. The *gur* made from the variety on the farm yielded a sucrose content of 72·31 per cent.

(The details of sections A and B have been kindly furnished by Messrs. Southern and Barnes respectively.)

2. LIST OF SPECIMENS EXAMINED.

Six months old.—(a) Gurdaspur, September 1913. Farm plot, irrigated ; 12 canes examined of which six were measured as to joints, leaf-sheaths and laminas. The canes were drawn and the crop photographed.

Ten months old.—(b) Gurdaspur, January 1913. Farm plot, irrigated ; 25 canes examined of which 20 were measured as to the thickness and length of their joints. The canes were drawn, painted and photographed.

About twelve months old.—(c) Gurdaspur, March 1913. Cultivator's field, rainfed ; five canes examined, drawn and photographed to scale.

3. GENERAL CHARACTERS OF THE VARIETY.

Canes practically straight-sided, without prominent nodes, thicker than *Lalri* and much thicker than *Katha* and *Dhaulu* ; evidently a *Katha* form. Heavily bloomed, the bloom sometimes blackened. Colour of mature stem vinous, due to the red brown skin under the bloom, but not so strongly marked in the specimens as in *Lalri*. Red brown markings seen in the groove region and the canes smutted in the field. Ivory markings as in *Katha*, not abundant, chiefly in upper parts of the joints and sometimes passing through the bloom band. Growth ring in old joints bright, reddish brown and sharply defined. Circlet of hairs well developed, persistent, of strong parallel hairs, often brownish in colour ; a distinct scar band, often with minute black hairs intermingled. Buds small, rounded or polygonal, usually reaching the growth ring, except in the lowest joints. Bursting apparently near the apex,

but not well studied. Hairs on bud moderately developed, the minute black hairs being present or not. Leaves standing out as in *Katha* but much broader, the young tips showing the characteristic bend of *Katha* and *Lalri*. Lamina hardly channelled at the base. Leaf-sheath glabrous, with light coloured edges. Ligular processes as in *Katha*, varying from small to large.

4. CANE MEASUREMENTS.

Dead leaves at six months old.—The six months canes had an average of seven dead leaves.

Length of six months canes after stripping dead leaves.—The canes averaged 2' 7", and the shoots 7' 9". From this it would appear that *Kansar* does not mature so rapidly as most of the other canes, but it may be that the leaves have a longer period of growth.

Total length of cane and number of joints at six and ten months—

- (a) six months 63·7" with 18·5 joints.
- (b) ten months 64·9" with 20·0 joints.

Total length of stripped cane divided by average thickness at middle l÷t.—(a) 103, (b) 109.

Length of joints in different parts of the cane, in inches :—

- (a) average of 6 canes; 2·5, 3·7, 4·1, 4·3, 5·2, 5·4, 4·8, 4·6, 4·8, 4·6, 4·4, 4·1, 3·9, 3·7, 2·5, 1·5, 0·8, 0·3, 0·1.
- (b) average of 20 canes; 2·5, 3·8, 4·7, 5·3, 5·4, 5·7, 6·0, 5·2, 4·7, 3·9, 3·6, 3·2, 3·1, 2·8, 1·9, 1·4, 0·8, 0·5, 0·3, 0·1.
- (c) The joints were usually longest about one-third of the way up.

The same tendencies are noticeable in this, as in other varieties, for the canes from older plots to have longer joints, especially at the base, and for their terminal joints to decrease in length less rapidly, facts which are more fully dealt with elsewhere.

Thickness of the cane at various points.—The canes of *Kansar* are usually fairly uniform in thickness all the way up. Sometimes there are a few narrow joints at the very base, succeeded by others

thicker than those in the middle, and this, although not shown in the figures, indicates a slight narrowing upwards. In other cases the youngest, immature joints at the top are swollen and barrelled. Average of 20 canes (b) base 0·56"; middle 0·59"; top mature 0·58".

5. COLOUR OF CANE.

The colour of *Kansar* is rather difficult to describe. It is a heavily bloomed cane and the thickness of this layer has a very great effect on the colour, and the bloom is heaviest in the mature joints. There is a white bloom band heavily descending and often a good deal dulled by blackening. The mature joint becomes vinous above because of a brown skin beneath the bloom, further up the cane there are pinkish streaks and blotches below the bloom band and, ultimately, the joints are yellow or green with pink markings. The youngest joints have less bloom and are at first apple green, then glaucous green or yellow, often with brown blotches.

The *growth ring* is olive green in the youngest parts, becoming light brown and ultimately a bright, reddish brown and very sharply defined.

The *root zone* is heavily bloomed, usually of a light cream colour, but becoming bone yellow and sometimes blackened below.

There is sometimes a good deal of *blackening* of the joints, especially on the upper parts of the lower ones. The joints do not *blush* on exposure to light between the gaping leaf-sheaths.

Below the leaf scar there is no definite sharp dark line, but a diffused grey to blackish grey zone between the scar and the bloom band. This is a typical *scar band* and there are often minute black hairs present in it.

The *groove* has the red mark so characteristic of *Katha*, seen under the lens to be composed of minute, parallel red brown lines; cases of black incrustation have also been met with.

The *ivory markings* are present, although not abundant, usually in the upper parts of joints and changing into splits. They

sometimes penetrate the bloom band and are present occasionally in the root zone. Here, as in *Katha* and other canes, an occasional joint near the top is seen to be covered by ivory markings close together in the middle of the joint, reminding of the markings typical of *Tereru*. These often change into splits.

6. CHARACTER OF THE JOINT.

Thickness, ovalness in section.

Kansar is a thick cane as far as those in the Punjab are concerned. It is thicker than *Katha* and *Dhaulu* and, in the field, than *Lalri*. The average thickness in the middle was as follows :—

- (a) Six canes 0·58" to 0·65"; average 0·62".
- (b) Twenty canes 0·48" to 0·59"; average 0·59".
- (c) Five canes, thickest 0·68"; thinnest 0·55".

Ovalness is not usually marked, lateral and medial measurements being :—

- (b) bottom of cane 0·56" + 0·58";
- middle of cane 0·59" + 0·61";
- top of cane 0·58" + 0·60";
- (c) thickest cane 0·68" + 0·68"; thinnest 0·55" + 0·61".

Length of the mature joints.—The canes examined had tolerably long joints, the extremes being 3 to 8 inches.

- (a) of 6 canes, shortest (basal) 2·5"; average longest 5·6"; average mature 4·2".
- (b) of 20 canes, shortest (basal) 2·5"; average longest 6·0", average mature 4·5".
- (c) the joints varied from 4 to 8 inches in length.

Shape viewed medially.—Thickest at leaf scar and root zone; growth ring often rather low and the rest practically straight. This gives the lower part of the joint a slight tendency to narrow upwards.

Shape viewed laterally.—There is sometimes a slight swelling below behind which gives the cane a slightly concavo-convex appearance. The joints are, however, practically straight.

Leaf scars not appreciably or very slightly descending and without a definite *lip*.

Circlet of hairs well developed, present in all joints, of strong, straight, parallel hairs, often discoloured.

Scar band present, distinct, often with minute black hairs.

Groove present, indicated or absent, often a flattened place, with the red brown marks of *Katha* and sometimes the harsh black incrustations.

Root zone moderately broad, usually not swollen, covered with bloom, sometimes with ivory markings; with 2-3 rows of eyes. Occasionally slightly tubercled, especially below.

Growth ring not very broad or pronounced. In old canes sometimes rather prominent, because of the dark brown colour; but more usually of a light brown tint and flattened.

7. BUD.

The buds of *Kansar* were found to be *shooting* in the six months' crop, but not in the others examined. To all appearance the *bursting* of the buds is more or less apical, except in a few lower joints where it is dorsal.

They are small, rounded or polygonal, usually reaching the growth ring, but sometimes falling short of it in the lowest joints; they usually arise at the leaf scar.

The *flanges* are rather well developed and arise at or slightly above the middle and pass round the apex.

The *bristles* are moderately developed, the *basal patches* well shown, of white glistening parallel hairs, and the *minute black hairs* present or not.

8. LEAFY SHOOT.

The leaves are rather widely separated on the stem and stand out much as in *Katha*; the leaf ends are erect, but some soon show the characteristic bend of *Katha*,

Number of terminal joints under 2", four in the six months canes and six in the ten months.

(a) 2·5", 1·5", 0·8", 0·3", 0·1".

(b) 2·8", 1·9", 1·4", 0·8", 0·5", 0·3", 0·1".

9. LEAF-SHEATH.

Length, average longest.

Average of the six months canes in inches, 7·9, 9·2, 10·3, 11·5, 11·9, 12·0, 12·0, 12·0, 12·3, 11·9, 11·6, 11·2, 11·1, 11·0, 10·9, 10·7, 10·7, (9·7, 7·3, 2·2, 0·4, 0·1).

Average longest 11·3.

The dying sheaths do not fade to a crushed strawberry as in *Dhaulu* and the sheaths are little bloomed. The *edges* of the young leaf-sheaths are light coloured as in *Katha*. *Silicious spines* are absent and the *hairs* between the veins behind are distinctly visible under the lens, white above and black below. Bases of sheaths *clasping* the stem rather widely.

Proportion of base of lamina to top of sheath, 14 : 19 and 14 : 20, in two canes.

The *ligular processes* vary, they are often large and on one side only.

Ligule narrow, with minute hairs along the edge.

10. LAMINA.

Average width 1·0" to 1·3".

Length, average in six; six months canes, 1'9", 2'4", 3'2", 3'2", 3'2", 3'6", 3'10", 3'11", 3'9", 3'11", 4'1", 4'1", 4'1", 4'0", 4'1", 4'2" 4'2", 4'3", 4'3", 3'11", 3'2", 2'4", average longest 4'4".

Proportion of length to width, 40 : 1.

Hardly *channelled* at base in the field, although seen to be so in the specimens in the laboratory. *Transverse marks* yellowish green, soon bloomed and dulled below. *Serrature* strong in young leaves, soon disappearing, except at the tips.

DESCRIPTION OF PLATE.

KANSAR.

1, 2. A lower and a middle portion of a ten months cane. The buds (6, 7, 8, 9) are shorter in the lower joints and do not there reach the growth ring. The circlet of hairs is strong and persistent. Ivory markings are present on the root zone at the base, of 1.

3. Lamina and sheath at their junction, showing a distinct, though short ligular process.

4. A portion of the ligule with a fringe of minute hairs on its edge.

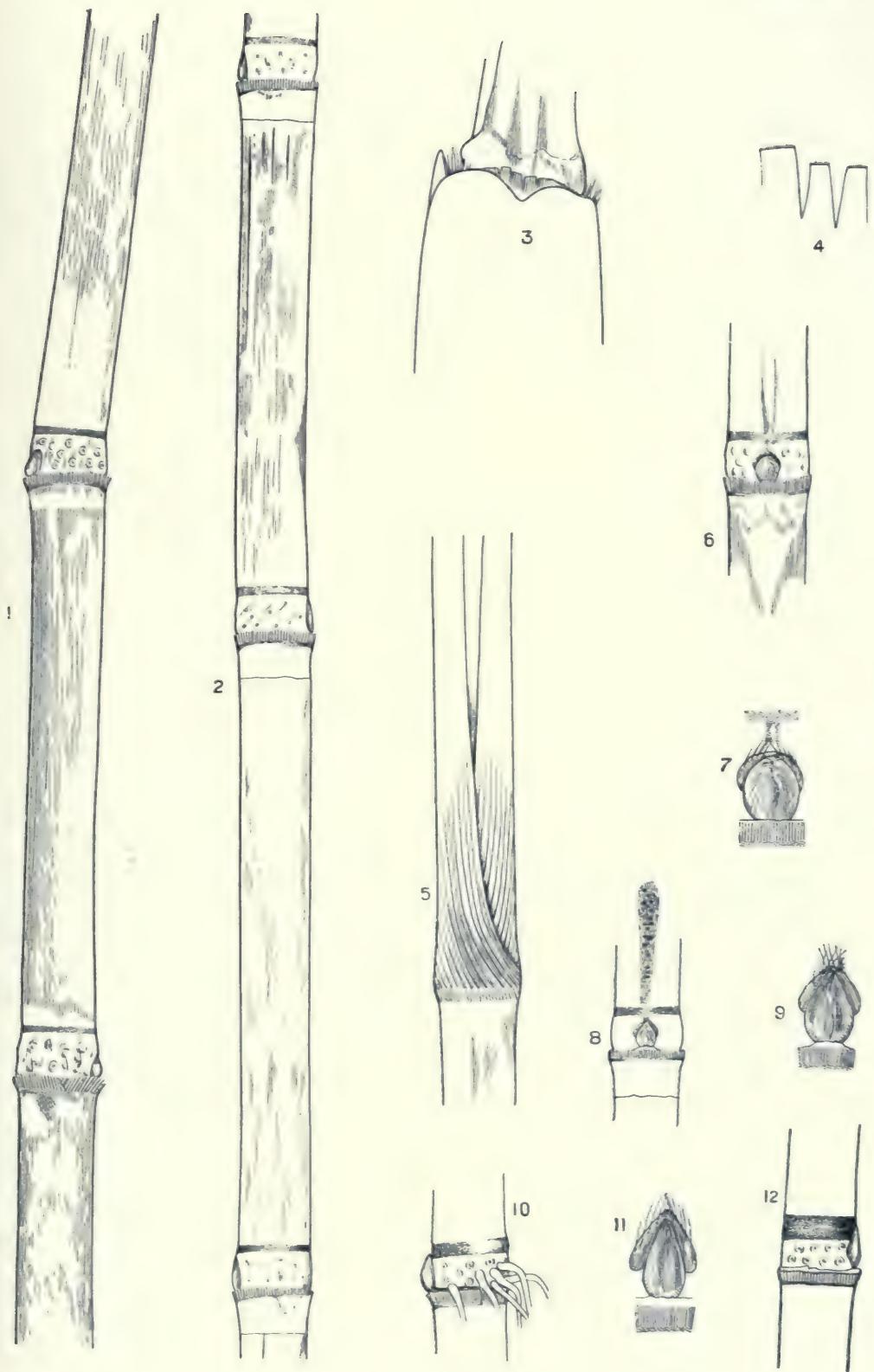
5. An uppermost joint showing the base of the leaf-sheath widely clasping the stem ; the circlet of hairs is still present.

6, 7. The upper node of 1 showing the medial view and the enlarged bud. The bud is short and does not reach the growth ring.

8, 9. The middle joint of 2. The bud is longer, has well defined basal patches and there is a black incrustation in the groove above the bud.

10. A lower joint of another cane, showing the roots emerging and a very well developed dark brown growth ring. There are ivory markings, on the root zone. The bud reaches the growth ring.

11. Another joint with very broad growth ring and rather elongated bud. The scar band is well shown in this and most of the other figures.



KANSAR.



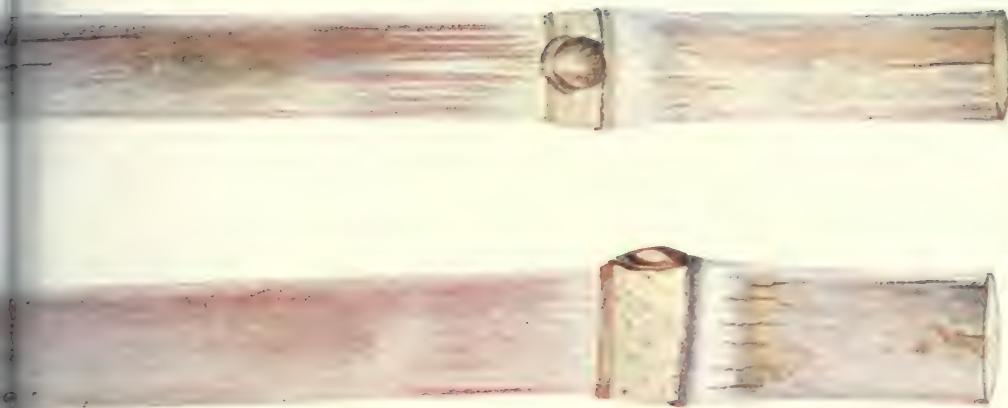
KANSAR. GURDASPUR
(The lines are one inch apart.)



KANSAR, GURDASPUR, 6 MONTHS OLD.
(The white mark on the bamboo is just under 6 feet.)



KANSAR



LALRI



KATHA



DHAULU OF GURDASPUR.

1. GENERAL REMARKS ON DISTRIBUTION AND AGRICULTURAL AND CHEMICAL CHARACTERS.

A. This variety is confined to irrigated land in Gurdaspur and adjoining districts. Outside of that tract it is seldom found and does not appear to thrive anywhere as well as in the Gurdaspur district. It is occasionally found, as is also *Tereru*, in Jullunder, Ludhiana and Ambala districts as a mixture in crops of *Dhaulu of Phillaur*. The two Gurdaspur kinds are not distinguished then and both are classed as *Ghorru* and are disliked as they are said to yield very inferior juice.

Dhaulu of Gurdaspur is green when unripe and becomes white later, as is indicated by its name. It is thicker than *Katha* and requires better soil and a more liberal supply of water. It is occasionally found under *barani* conditions but is nearly always irrigated. It ripens later than *Katha*; the leaves are more easily stripped and the rind is softer. The sets at planting time are more liable to be attacked by white-ants. This applies to all the kinds grown, *Katha* being the most resistant; the thicker the cane the more readily is it attacked. The *gur* is of a better colour and the sugar whiter than in *Katha*, but the *gur* is said not to keep so well. (The six months canes were 9-10 feet high at Gurdaspur and the ten months higher still. The canes were erect, in bunches, often covering the ground thickly, but falling at the edges of the field or where the growth was very luxuriant, then often being crooked and lying down. The older leaves stand out from the stem as in *Katha*. Tillering is very good but depends on the closeness of planting and evenness of germination. Where thinly planted very large numbers of shoots have been noted rising from one stool. I should call the young canes glaucous green and the old, fully ripe ones, clear

bone yellow but the term white is often applied as distinguishing yellow canes from green. Rooting occurred at from two to four of the lowest joints, but was not marked ; shooting was rare in the specimens examined. The plants were only slightly attacked by smut, which seems to be rather typically present in the *Katha* alliance, but a good deal of *Fomes lucidus* was found in places. As indicated below, *Dhaulu* of *Gurdaspur* closely resembles *Katha* but is distinguished by a large number of minute differences, which would hardly have been studied but for the closeness of the two canes. It would seem that *Dhaulu* may be a colour variety, more delicate and therefore adapted to more generous treatment. The canes examined were chiefly those grown on the *Gurdaspur* Farm or obtained in its neighbourhood. Since my last visit Mr. Southern has drawn attention to the fact that this cane does not agree with that under the same name further west, and some canes of the latter sent down have been separated under the name *Dhaulu* of *Phillaur*.—C. A. B.)

B. A fine soft cane yielding *shakkar* on good soils. The variety is classified as "quickly affected by frost but quickly recovering." The average composition of the juice (average of the last three years) is :—

Month.			Sucrose %	Invert sugar %
November	..	..	12·21	2·51
December	..	..	13·00	1·48
January	..	..	14·44	1·34
February	..	..	15·70	0·66

It is fully ripe about the end of January. The *gur* or *shakkar* made from various specimens of the variety yielded a sucrose content from 67·62 per cent. to 76·0 per cent.

(The details of sections A and B, have been kindly furnished by Messrs. Southern and Barnes, respectively).

2. LIST OF SPECIMENS EXAMINED.

Young canes—Six months old. (a) *Gurdaspur*, September 1913. Irrigated farm plot (canes from Bham) ; six canes examined and

six others measured as to length of joint, leaf-sheath, and lamina ; canes drawn and photographed to scale, leaf parts drawn, crop photographed.

Mature canes ten months old. (b) Gurdaspur, January 1914. Irrigated farm crop (local canes) ; 25 canes examined of which 20 were measured as to thickness and length of joint ; five others selected for drawing, painting, and photographing to scale ; crop photographed.

Mature canes twelve months old. (c) Gurdaspur, March 1913. From a cultivator's field ; six canes examined, drawn and photographed to scale ; habit photographs taken in the field.

(d) Harchowal, March 1913. Cultivator's field ; canes examined and photographed to scale.

Besides these, 18 canes were obtained in September 1913, from Jullunder. These were examined and the canes drawn, but there were puzzling differences noted at the time, and it now seems probable that the canes were examples of the more eastern *Dhaulu of Phillaur*. They are not, therefore, included in this description.

3. GENERAL CHARACTERS OF THE VARIETY.

Dhaulu of Gurdaspur is a taller and thicker cane than *Katha* of the same district, and the leaves are broader and of a fresher green. It is usually an irrigated crop, which limits its region, and is more delicate than *Katha* against frost. The canes are thin, straight-sided, the nodes, perhaps, a little more prominent than in *Katha*. The colour of the stem is glaucous grey or green in young parts to clear bone yellow in older. The stem blushes readily on exposure to a vinous or purple, with brown skin under the bloom and, on being cut and stripped, turns a red pink in a few days. The characteristic red brown marks in the groove of *Katha* are absent in *Dhaulu*. Ivory markings are not uncommon but the canes vary, from practically none, to so many that a separate variety (*Tereru*) has been instituted by the cultivators. These ivory markings are usually confined to the upper two-thirds of the joint and do not penetrate

the bloom band. There is usually a definite brown scar line as contrasted with the scar band of *Katha*. The growth ring is distinct, light brown in older joints. The circlet of hairs is usually present in the lower joints but soon disappears upwards, especially under the bud, or changes to a felt of small hairs. The buds are similar to those in *Katha*, small, but reaching the growth ring ; they usually burst, however, more or less apically and appear to be rather better provided with hairs ; minute black hairs are generally present. The leaf-sheaths turn crushed strawberry colour on death in the six months canes and blush readily in the ten months canes, while their young edges soon turn red brown,—all of them characters distinguishing *Dhaulu* from *Katha*. The tips of the leaves do not bend sharply as in canes of the *Katha* alliance. The sheath does not clasp the stem broadly and ligular processes are absent or small.

4. CANE MEASUREMENTS.

Dead leaves at six months old, usually 14-15.

Length of six months canes after stripping dead leaves, the canes averaged 4'9" and the shoots 5'9".

Total length of cane and number of joints at six and ten months—

- (a) Six months old canes 72·8", with 25 joints ;
- (b) Ten months old cane 69·4", with 27 joints.

It is to be noted that (a) and (b), were not drawn from the same plot as was the case in all other varieties, and this may account for the fact of the six months old canes being longer. None the less, it is evident that most of the growth here, as in *Katha*, has already taken place by the end of September.

Total length of stripped cane divided by average thickness at middle, l ÷ t.

- (a) 142 (b) 142.

Length of joints in different parts of the cane, in inches :—

- (a) 1·7, 2·3, 2·7, 2·9, 3·3, 3·6, 4·0, 4·5, 4·7, 4·8, 4·9, 4·6, 4·1, 3·5, 3·7, 3·7, 3·1, 2·7, 2·4, 2·2, 1·8, 1·2, 0·6, 0·4, 0·1.

(b) 1·7, 2·3, 3·1, 3·3, 3·7, 3·9, 4·0, 4·1, 3·9, 3·7, 3·5, 3·5, 3·5, 3·3, 3·1, 2·9, 2·7, 2·4, 2·4, 2·1, 1·8, 1·4, 0·9, 0·8, 0·5, 0·2, 0·1.

There is little difference between these curves, excepting that the older canes show a slower rate of growth at the tip, as might be expected. The comparison in the curves, made in *Katha* and other canes, does not hold here and perhaps is due to the fact that the canes were not taken from the same plot in the two cases.

Thickness of the cane at various points.—In thickness the canes were fairly uniform all the way up, with a slight tendency to narrowing upwards.

Average thickness of 20 mature canes ten months old:—

(b) Bottom joint 0·50"; middle 0·48"; top mature 0·46". The maturer canes of this series of 20 tend to become thinner upwards, while those that are less mature tend to thicken upwards.

5. COLOUR OF CANE.

The canes in *Dhaulu* are glaucous green or greyish green when young, becoming clear bone yellow as they mature and *blush* dark vinous purple where exposed by the separation of the leaf-sheaths, the skin below this blush being clear light brown. There is sometimes a slight amount of *blackening*, especially in the upper part of the joint. The stems, after cutting, become a reddish pink which is very striking, those of *Katha* cut at the same time not or only very slightly assuming this colour. The youngest joints near the apex are clear apple green.

The *bloom band* is well seen in young canes or parts, but hardly forms a distinct band; it descends as far as the growth ring and covers the root zone heavily. The presence of the bloom changes the light green of the skin to a greyish glaucous green. The *growth ring* is light brown and distinct, becoming brownish yellow and ultimately green as one proceeds upwards to the young joints. The *root zone* is light straw coloured in mature joints, and cream coloured with heavy bloom in young ones. The *groove* does not

show the red brown marks so characteristic of *Katha*, but the harsh black incrustation has been occasionally noted.

Ivory markings are not uncommon in *Dhaulu*, but the canes vary considerably in this respect. As stated above, certain ryots attribute the abundance of these markings in *Tereru* to drought conditions, while others separate the heavily marked ones from *Dhaulu* under this name. The typical markings in *Dhaulu* are a series of parallel lines in the middle or upper part of the joint, not passing through the bloom band. They are not usually present in the root zone as in *Katha*.

There is a distinct *scar line* in *Dhaulu* of a brownish colour in old joints below the edge of the leaf-scar, but this is less definite in younger joints.

6. CHARACTER OF THE JOINT.

Thickness, ovalness.—*Dhaulu* has thicker canes than *Katha*, but they are still very thin. As will be seen from the figures, the farm canes seem to be thinner than those taken from the ryots' field:—

- (a) of 12 canes six months old, the average was 0·50";
- (b) of 20 canes ten months old, the average was 0·46" (0·37" to 0·57");
- (c) of 6 canes twelve months old, thickest 0·56", thinnest 0·45";
- (d) of 6 canes twelve months old, thickest 0·62", thinnest 0·46".

Dhaulu has a distinct tendency towards *ovalness*; thickness, lateral + medial:—

- (b) bottom of cane 0·50"+0·54";
middle , , 0·46"+0·49";
top mature 0·46"+0·52";
- (c) thickest cane 0·62"+0·66", thinnest 0·45"+0·47";
- (d) thickest cane 0·56"+0·60", thinnest 0·46"+0·52."

Length of mature joints.—*Dhaulu* on the whole has shorter joints than *Katha*, and this is emphasised by their greater thickness—

- (a) average length 3·4"; average shortest 1·7"; average longest 5·1";

- (b) average length 3·1"; average shortest 1·7"; average longest 4·5";
- (c) the joints of six canes were judged to be 3" to 5" long;
- (d) the joints of four canes were judged to be 2·5" to 4·5" long.

Shape viewed medially.—Thickest at leaf-scar, or at growth ring when that is swollen, narrowing towards the middle, hence, generally biconcave. This is seen especially in the shorter joints. The root zone usually narrows downwards, but is often swollen in the lower joints. The nodes are more marked than in *Katha*.

Shape viewed laterally.—Practically straight-sided and uniform. In some joints there is a distinct slight swelling below behind, but this is totally absent in others. A few canes have been met with which are distinctly zigzag.

Leaf-scar practically horizontal and without a definite *lip*. No descending *leaf-scar end*.

Circlet of hairs usually present in the lower joints but, passing upwards, it rapidly disappears, especially under the buds. It frequently changes early into a felt of hairs before disappearing.

Splitting does not appear to be very common; where noted, the splits were black in colour and obviously arose from ivory markings.

Groove often present as a flattened area, but never pronounced. Sometimes it has the black incrustation but not the red brown marks of *Katha*.

Root zone not very broad, narrowing downwards except in the lower joints. With 2-3 rows of rather distinct eyes, not tubercled except in the lower joints.

Growth ring distinct, with definite upper and lower boundary, hereby differing from *Dhaulu* of *Phillaur*. Narrow and flat or broad and raised; the latter was noted especially in the six months old canes where the growth ring was sometimes $\frac{1}{4}$ " wide and distinctly swollen,

7. BUD.

The buds examined were in no cases *shooting*. *Bursting* takes place high up, at or near the apex.

The buds are small to moderate in size, reaching the growth ring, ovate, pointed, sometimes broader than long at the base of the stem, but becoming narrower upwards and sometimes diamond shaped.

They usually rise at the leaf-scar but occasionally some have been seen rising a little above it ; no *cushion* was however seen.

The *flanges* are moderately developed and sometimes rather broad, rising below the middle and passing round the apex to a wide angle. They are often dark-coloured.

Bristles moderately developed of sparse, stiff hairs round the border of the flanges ; a tuft of silky hairs usually present at the place where the base of the flange meets the bud, on each side. The *basal patches* present, often ascending the veins of the bud and passing into the tuft of hairs. *Minute black hairs* far commoner than in *Katha*, chiefly in the basal patches and round the base of the bud.

8. LEAFY SHOOT.

There are 5-7 leaves in the *terminal tuft* (the last two inches of the visible shoot).

Leaf end not angled or bent as in *Katha*.

Number of terminal joints under 2", 5 in six months canes and 7 in the ten months :—

(a) 2·2", 1·8", 1·2", 0·6", 0·4", 0·1".

(b) 2·1", 1·8", 1·4", 0·9", 0·8", 0·5", 0·2", 0·1".

9. LEAF-SHEATH.

Length, average longest of leaf-sheaths in the six canes :—

(a) 7·9", 8·1", 8·8", 9·1", 9·2", 9·3", 9·5", 9·6", 9·8", 9·9", 10·3", 10·7", 10·5", 10·3", 9·9", 10·2", 10·3", 10·5",

10·4", 10·2", 9·8", 9·3", 8·9" (8·9", 8·5", 5·4", 0·9", 0·1"), average longest 11·0".

The leaf-sheaths are more easy to detach than in *Katha*, but the base breaks off and is difficult to remove.

Not or very slightly bloomed. The sheaths of the six months old canes turned a clear crushed strawberry colour immediately after death, then changing to a dull straw colour. The sheaths in the mature (10 months) canes, on the other hand, did not turn crushed strawberry but usually blushed deep red while living, especially the younger ones near the apex. These colorations were absent in *Katha*. The *scarious border* commences high up and before the death of the lamina edge. The edges of the young leaf-sheath soon become bright red brown.

The sheath is rough dorsally with a few *silicious spines*. The minute hairs between the veins behind are, as in *Katha*, puberulous and hardly distinct under a lens.

The hairs at the top of the sheath often *descend along the edges* for a short distance. The base of the sheath *clasps* the stem less widely than in *Katha*, only surrounding the circumference $1\frac{1}{4}$ times. The outer edge of the leaf sheath can be seen when viewing the shoot medially.

Proportion of base of lamina to top of leaf sheath, 0'65" to 1'00". In other cases the proportion was 13:16, 13:17, 14:16, figures showing a marked difference from those in *Katha*.

The *ligular processes* are consequently hardly present, sometimes small or indicated, never long as in *Katha*.

The *ligule* is rather narrow, but widens in the middle; the edges are covered as in *Katha* with minute hairs.

10. LAMINA.

Width 1·1" to 1·3".

Length in six months canes, averages from base upwards, 2'1", 2'8", 2'6", 2'8", 2'10", 3'0", 3'1", 3'2", 3'3", 3'5", 3'7", 3'7", 3'9", 3'9", 3'7", 3'7", 3'7", 3'8", 3'9", 3'10", 3'10", 3'10", 3'9", 3'8", 3'6", 3'2", 2'5".

Longest 3'11", 4'1", 4'1", 4'1", 4'1", 3'11", average 4'0".

Proportion of length to width, 37 to 1.

Not markedly channelled at the base and soon flattening out.

Transverse marks slightly blackish green and slightly bloomed ; the leaves lighter green than in *Katha*.

Serrature rather soft, persistent.

Proportional width of midrib to lamina.—At 1" from base, 18 : 100 ; at 6", 20 : 100 ; at 12", 15 : 100. The midrib is proportionately narrower than in *Katha*.

TERU OR TERERU.

I. GENERAL REMARKS ON DISTRIBUTION AND AGRICULTURAL AND CHEMICAL CHARACTERS.

A. This cane is very like *Dhaulu* of *Gurdaspur* but with ivory markings. In *Gurdaspur* district, where it is commonly found mixed with the local *Dhaulu*, it is looked upon as a fairly good quality cane and the presence or absence of ivory markings is said to be a question of weather conditions. Sometimes a crop from typical *Teru* seed will, in the next year, show no ivory markings, it is said. On the whole *Dhaulu* is preferred to *Teru* in the *Gurdaspur* district. In parts of *Jullunder*, *Ludhiana* and *Ambala* districts it is occasionally met with as a mixture in the *Dhaulu* of *Phillaur* crops. Generally then the ivory markings are present but occasionally they are absent and then the cane is identical with the *Dhaulu* of *Gurdaspur*. In both cases the cane is known as *Ekkar* or *Ghorru* and is much disliked, as it is said to yield very inferior juice and the better cultivators discard it when selecting cuttings for seed. In the *Samrala* Tehsil of *Ludhiana* district the ivory markings are sometimes very heavy indeed. (There appears to be no real morphological difference between *Tereru* and *Dhaulu* of *Gurdaspur*. The name signifies, I am told, a streak, and the cane is distinguished by the greater number of ivory markings which it shows on the stem. These markings are however explained in different ways by the cultivators. Some state, as noted already, that their presence indicates a condition of drought, while others steadfastly adhere to the opinion that *Tereru* is a different cane from *Dhaulu*. It appears to me that the specimens which were brought to me were sought out for their abundance of ivory markings and I suspect that they were drawn equally from *Dhaulu* and *Tereru* plots. That the markings are not constant is, I think, shown by the fact that

of the 20 canes examined at Gurdaspur, sown from typical *Tereru* cuttings only seven had the markings at all in evidence. It was also found quite possible to obtain typical *Tereru* canes from the *Dhaulu* plot. After a careful morphological study, no intrinsic difference was found between the two canes. Taking these facts into consideration it was deemed unnecessary to detail a full description of this cane from the accumulated notes. The measurements are however given as these do not altogether agree with one another nor with those given for *Dhaulu*. Further study may show that these two canes represent different conditions and such are likely to be evidenced by the growth of the canes.—C. A. B.)

B. A soft cane generally yielding *shakkar* on good soils. The variety is classified as semi-resistant to frost on the results of the last three years' experiments. The average composition of the juice (average of the last three years) is :—

Month.		Sucrose %	Invert Sugar %
November	..	13.32	1.37
December	..	13.84	1.48
January	..	14.24	1.14
February	..	16.99	0.71

The variety ripens late in February. The sample of *gur* made from it on the Agricultural Station at Gurdaspur yielded 68.15 per cent. of sucrose.

(For the details of sections A and B, I am indebted to Messrs. Southern and Barnes respectively).

2. LIST OF SPECIMENS EXAMINED.

Canes about six months old.

(a) Gurdaspur, September 1913. Farm plot, irrigated ; 12 canes examined of which six were measured as to joint, leaf-sheath and lamina. The canes were drawn and the plot photographed.

Canes about ten months old.

(b) Gurdaspur, January 1914. Farm plot, irrigated : 25 canes examined of which the joints were carefully measured in 20. The

canes were drawn and photographed to scale, a typical joint was painted and the field was photographed.

Canes about twelve months old.

(c) Gurdaspur, March 1913. Cultivator's field, rainfed ; 7 canes were examined and photographed to scale.

(d) Harchowal, March 1913. Cultivator's field ; 6 canes were drawn and photographed to scale.

3. GENERAL CHARACTERS OF THE VARIETY.

These have been mentioned above and the differences from *Dhaulu* discussed.

4. CANE MEASUREMENTS.

Number of dead leaves at six months old, 10 to 15, averaging 13.

Length of cane and shoot after stripping these : cane 3'3", shoot 6'7".

Total length of cane and number of joints at six and ten months.

(a) Total length 66·1", number of joints 24.

(b) Total length 70·6", number of joints 24.

Total length divided by average thickness at the middle, $l \div t$,

(a) 130, (b) 150.

Length of joints in different parts of the cane, in inches :—

(a) 1·0, 1·5, 1·9, 2·2, 2·7, 3·3, 3·8, 4·0, 4·2, 4·1, 3·8, 3·7, 3·5, 3·4, 3·7, 3·5, 3·5, 3·2, 2·7, 2·2, 1·3, 0·6, 0·3, 0·1.

(b) 3·1, 3·6, 4·1, 4·6, 4·5, 4·4, 4·2, 4·2, 4·4, 4·3, 4·0, 3·9, 3·8, 3·4, 3·1, 3·1, 2·8, 2·2, 1·6, 1·0, 0·7, 0·5, 0·3, 0·1.

Here, as in *Katha*, the curves of the six months and ten months canes differ very considerably, the older canes showing much longer joints near the base and shorter ones near the apex.

Thickness of the cane at various points.

(b) Average of 20 canes, base 0·47", middle 0·45", top mature 0·46". These differences are immaterial and the cane appears to be of practically the same thickness all the way up. It is to be

noted however that these measurements are of mature joints and that the youngest, immature joints at the top, were often swollen and barrelled.

6. CHARACTER OF THE JOINT.

Thickness, ovalness.

(a) Twelve canes measured at the middle; thinnest 0·45", thickest 0·60", averaging 0·50"

(b) Twenty canes measured laterally + medially :—

base 0·47" + 0·50", middle 0·45" + 0·48", top mature 0·46" + 0·50".

From these measurements *ovalness* is not a marked character.

(c) Seven canes, thickest 0·54" + 0·58" thinnest 0·44" + 0·46".

(d) Six canes, do. 0·58" + 0·61" do. 0·50" + 0·52".

Length of mature joints.

(a) Six canes, average length 3·1", average longest 4·4", average basal 1·0".

(b) Twenty canes, average length 3·7", average longest 4·8", average basal 3·1".

(c) Seven canes, joints judged to be 3" to 5" long.

(d) Six canes, joints 2·5" to 4·0" long.

9. LEAF-SHEATH.

(a) Six months canes; average longest 10·2"; averages of the six canes in inches :—

7·4, 7·6, 7·9, 8·1, 8·0, 8·4, 8·6, 8·7, 8·9, 9·4, 9·6, 9·9, 10·1, 10·1, 9·9, 9·7, 9·3, 9·4, 9·7, 9·7, 9·4, 9·4, 9·2 (8·7, 7·8, 3·2, 0·7, 0·1).

10. LAMINA.

Width 1·0 to 1·2".

Length—Average lengths of the leaves from base to apex :—
1'11", 2'1", 2'5", 2'5", 2'7", 2'8", 2'9", 2'11", 3'1", 3'3", 3'5", 3'5", 3'6", 3'8", 3'7", 3'8", 3'7", 3'6", 3'6", 3'7", 3'6", 3'7", 3'5", 3'3", 2'7", 2'2".

Average longest lamina, 3'9".

Proportion of length to width 37·5:1.

DESCRIPTION OF PLATE.

DHAULU OF GURDASPUR, TERERU.

1. A six months cane with rather broad growth rings taking part in the curvature of the cane.

2. A ten months cane, slightly zigzag; the circlet of hairs is absent and a distinct scar line is seen below the dark leaf scar.

3. Lamina and sheath at their junction. There is no ligular process.

4. A portion of the ligule with a fringe of minute hairs on its edge.

5, 6. The middle joint of 1 with its bud enlarged. There are few bristles in the latter, but there is a slight cushion below the bud. The circlet of hairs is not present but the top of the leaf scar bears a series of parallel grooves.

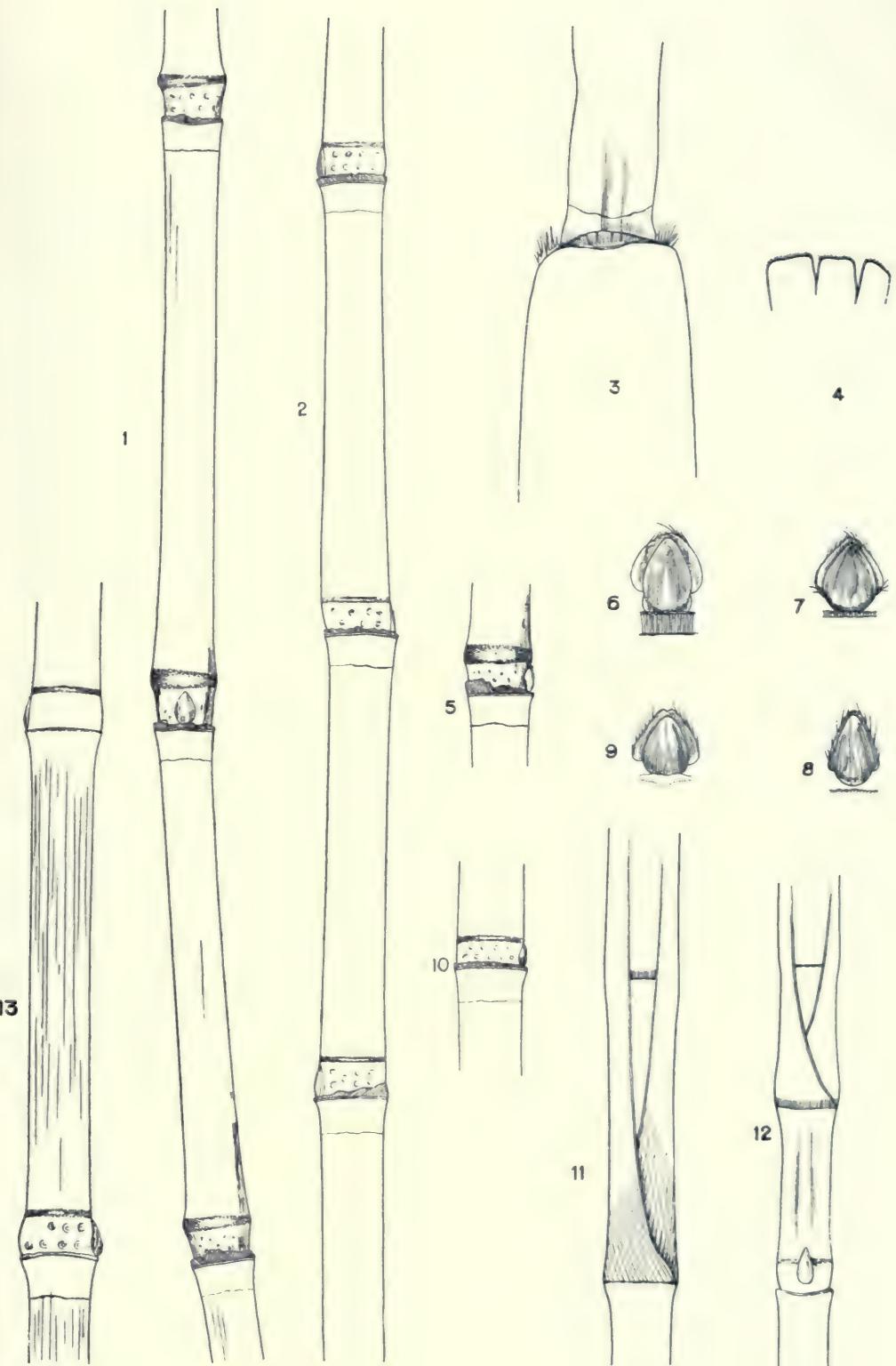
7. Another bud of the same cane with tufts of hairs at the bases of the flanges. In 6 and 7 minute black hairs are seen at the base of the bud.

8. A bud from a young, upper joint, more elongated than usual and rising slightly above the leaf scar.

9, 10. A lower joint of cane 2 with narrow root zone. Its bud shows apical bursting.

11, 12. Upper joints of cane with base of leaf sheath clasping the stem round one and a quarter times its circumference. In 12 the bud is elongated and rises a good deal above the leaf scar.

13. A joint of *Tereru* with characteristic ivory markings.



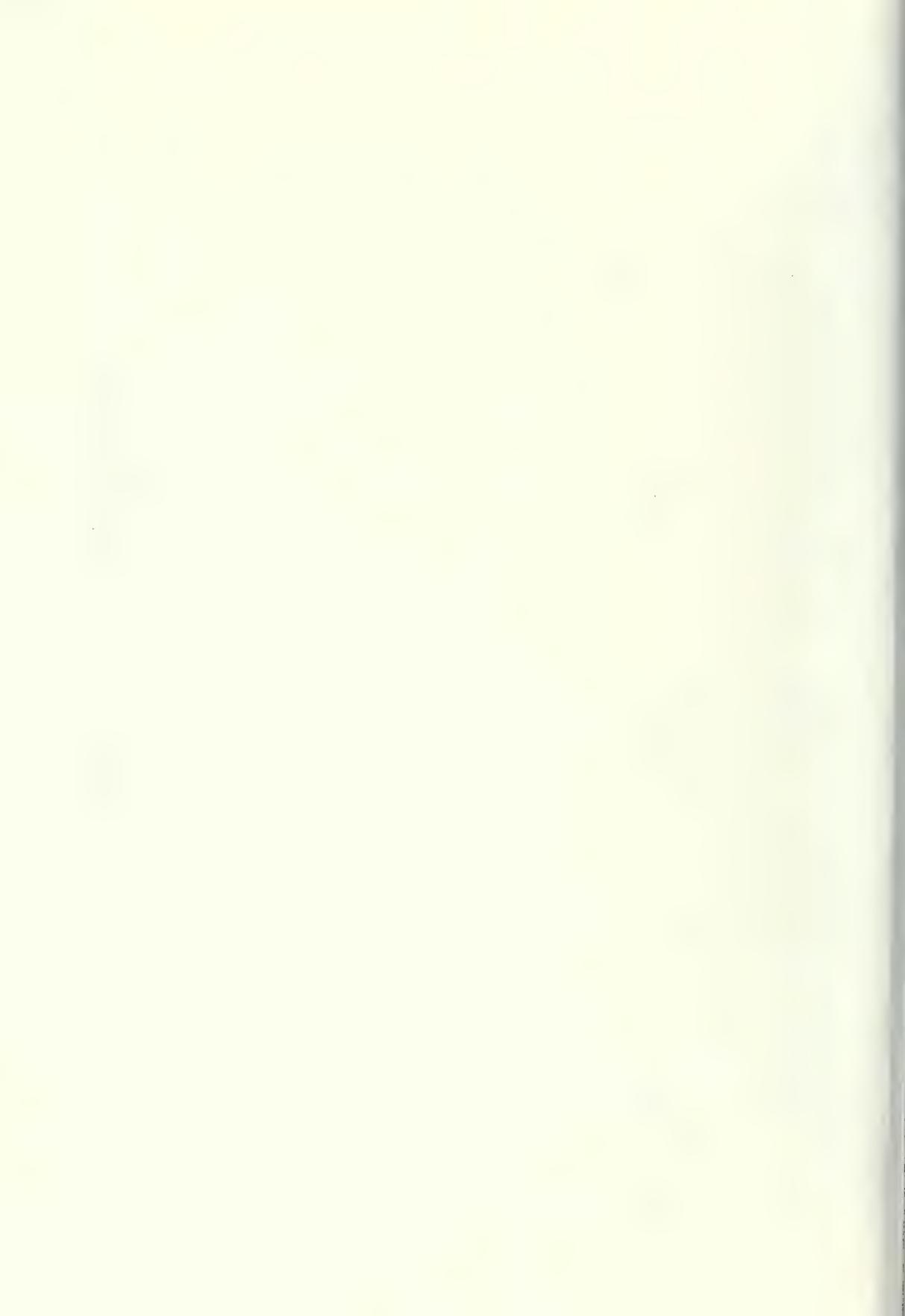
DHAULU OF GURDASPUR. TERERU.

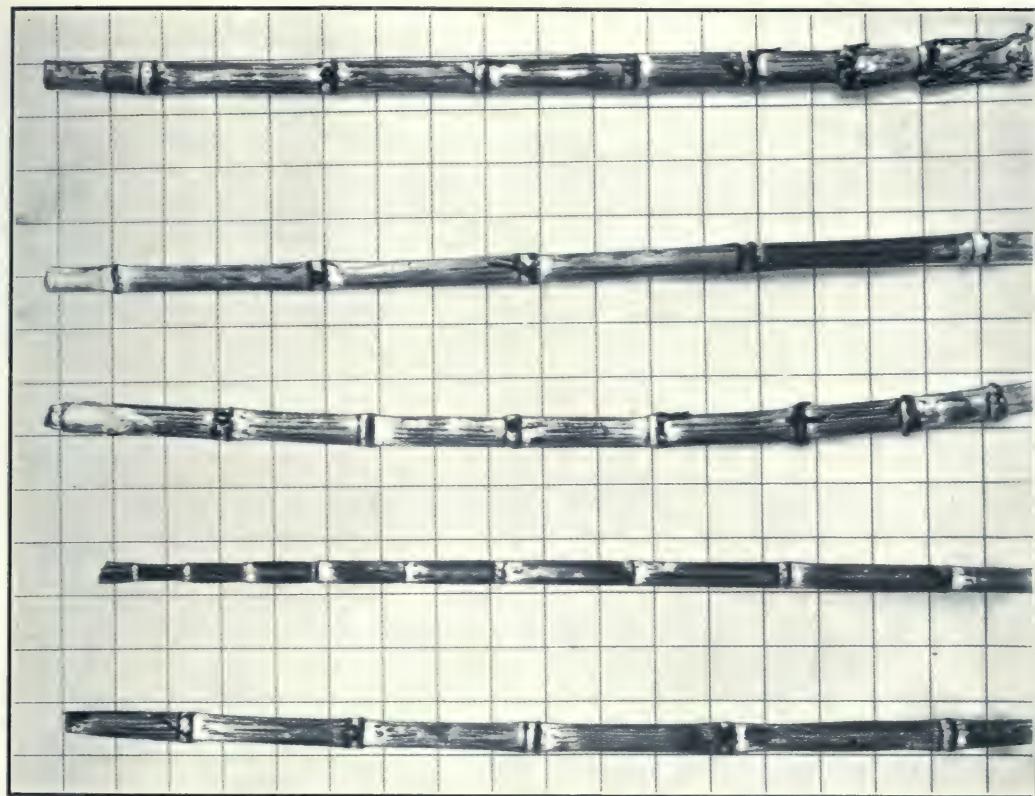


DHAULU GURDASPUR. 6 MONTHS OLD.
The black mark on the bamboo is just under 6 feet.

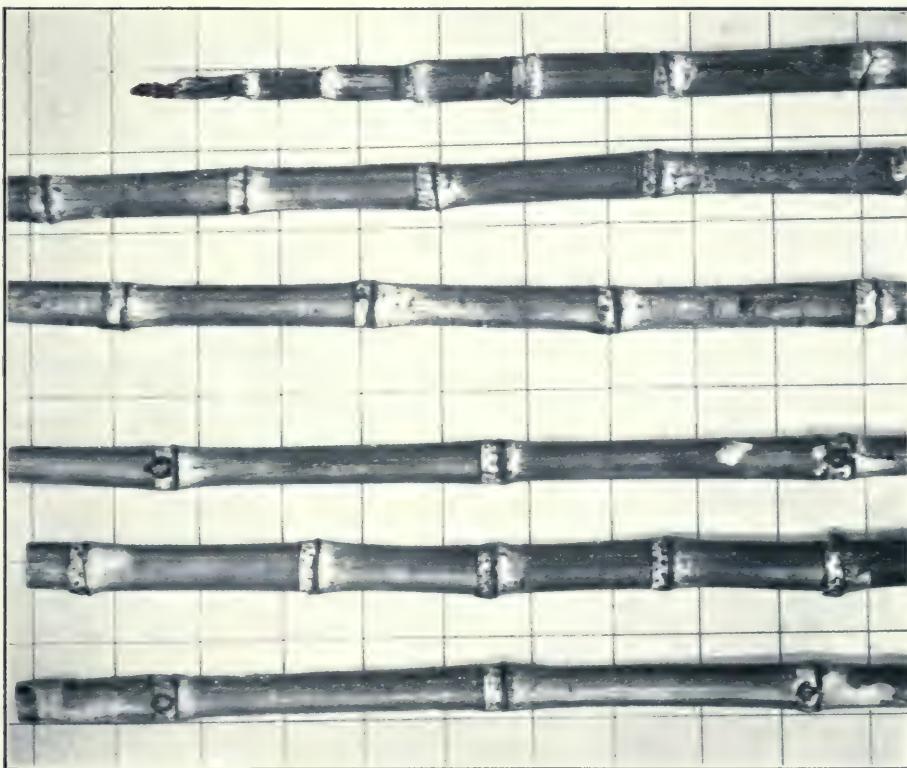


DHAULU GURDASPUR.

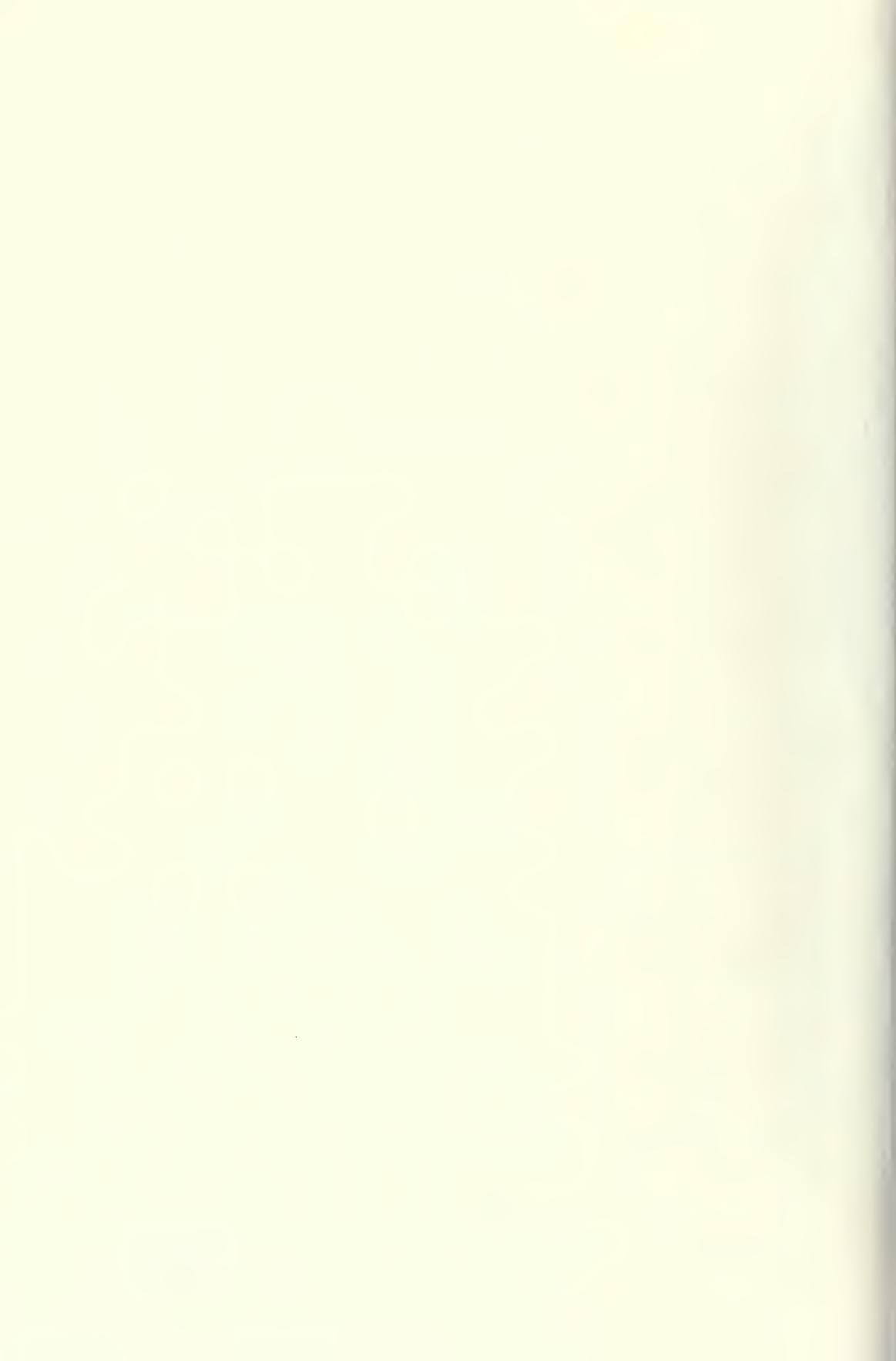




TERERU, GURDASPUR.
(on smaller scale)



DHAULU OF GURDASPUR.



DHAULU OF PHILLAUR.

1. GENERAL REMARKS ON THE DISTRIBUTION AND CLASSIFICATION OF THIS CANE.

A. Found in submontane tracts of Jullunder, Ludhiana and Ambala districts, also to a less extent in Hoshiarpur and the north of Karnal. From the agricultural point of view this variety is very like *Dhaulu of Gurdaspur*, in the general habit of growth, time of ripening and outturn and quality of *gur*. On close examination it is found to have a very broad root zone and no pronounced growth ring, differing in both these respects from *Dhaulu of Gurdaspur* and *Tereru*. The buds thus seldom reach the growth ring. The joints are also much bulged on the side opposite to the bud, thereby giving the cane a somewhat different appearance when cut.

(I am indebted to Mr. Southern for the above information.)

B. As stated in the Introduction, I have not met with this cane in the field. Shortly after my last visit to Gurdaspur in January 1914, Mr. Southern, touring in the Ludhiana and Jullunder districts and fresh from the study of the varieties collected at Gurdaspur in which he took much interest, wrote to say that he was convinced that the *Dhaulu* met with in these two districts was distinct from that in Gurdaspur. Specimens were accordingly sent down to Coimbatore where they were at once seen to be an additional member of the Punjab canes, differing in several important respects from the *Dhaulu* already examined from Gurdaspur. The canes sent down form the basis of the present description. They were not however entirely new to me for the following reasons :—

(1) Some specimens of *Dhaulu* obtained from Jullunder in September 1913 were noted as differing in several important respects from the local *Dhaulu of Gurdaspur* and threw at the time doubt on the fixity of the characters observed in that cane.

(2) In examining *Kanara of Jullunder*, grown for some years on the Gurdaspur Farm, in January 1914, certain canes were seen in the sample of a glaucous green in place of the bright green of the *Kanara* and, on further examination, proved to be a quite different cane.

(3) The *Dhaur* element of *Dhaur-Kinar*, from Meerut separated out by the farm staff at Gurdaspur, was examined and measured because I had failed to obtain good examples of this mixture at Aligarh. This variety was drawn and measured, and proves to belong to the same series.

(4) A cane of a similar nature called *Bodi*, growing at Gurdaspur and received some years ago from Aligarh, was gone through as if it was a Punjab variety, there being some doubts as to whether it had not crept into the more eastern districts.

All four of these are practically indistinguishable from the *Dhaulu of Phillaur*, excepting by some slight differences in thickness and other minor points. It was therefore without difficulty that the diagnosis was made at Coimbatore from the canes sent down. *Dhaulu of Phillaur* is a cane of the *Mango* class, and this is of special interest in that I had concluded that this eastern section of the North Indian canes was not represented in the Punjab. But it differs in some points from the typical members of the section. The canes are longer and thinner and grow to a greater height in the field than is usual. The *Mango* class appears to undergo this change in its migration towards the north-west and *Dhaulu of Phillaur* may be taken as representing the extreme limit of this elongation, and in fact may be, for the time, considered as a connecting link between the primitive *Dhaulu of Gurdaspur* and the short thick canes of the *Mango* class of the United Provinces and Bihar.

2. SPECIMENS EXAMINED.

The canes forming the basis of the following descriptions and measurements were received at Coimbatore during the 1914

cropping season. No opportunity has been afforded of studying the foliage characters. The specimens have apparently come from the neighbourhood of Phillaur.

3. GENERAL CHARACTERS OF THE VARIETY.

Canes thin, practically straight-sided but slightly zigzag in lateral view, without prominent nodes, and leaf scars descending. Colour glaucous green to yellow below, yellow in lower parts of joints. Ivory markings present in all parts but lower joints often free; usually as a few long dark lines in the middle of the joint, passing through bloom band or not; sometimes anastomosing to a dense net-work. Scar line definite, dark brown. Growth ring practically non-existent as a separate layer, this character distinguishing *Dhaulu* of *Phillaur* from all other Punjab canes. Root zone broad, with ill-arranged widely separated root eyes. Circlet of hairs present, the hairs short and numerous. It however soon disappears upwards, especially under the bud, although traces are met with at other places most of the way up the stem. Buds small, rounded, sometimes blackening at base, bursting apically as a rule not nearly reaching the region of growth ring—another characteristic feature. Hairs not well developed; minute black hairs present. A few spines on the back of the leaf sheath in the specimens received, and the ligules rather large, arched above and with a fringe of fine silky hairs.

4. CANE MEASUREMENTS.

Total length of cane, average of 18 canes, 59·5" with 22·7 joints.

Total length divided by average thickness at middle, $l \div t$. 97.

Length of joints in different parts of the cane, in inches :—1·6, 2·3, 2·8, 3·7, 4·3, 4·5, 4·6, 4·7, 4·6, 4·3, 3·9, 3·5, 3·2, 2·9, 2·2, 1·7, 1·4, 1·0, 0·8, 0·5, 0·3, 0·2, 0·1.

There are an unusually large number of terminal joints under 2" in length, a characteristic feature of the *Mango* group.

Thickness of the cane at various points.

(b) Base 0·59", middle 0·60", top mature 0·59". These figures show an average cane of surprisingly uniform thickness all the way up.

6. COLOUR OF CANE.

Glaucous green to yellow below ; lower parts of the joints yellower. *Bloom band* visible, chiefly on younger parts, not well defined below these ; descending distinctly but not thickly over the joint, giving a glaucous green above and whitish yellow below ; hardly, thinly covering the growth ring and root zone.

Growth ring often scarcely a defined ring, but sometimes seen as a narrow and darker band above the root zone. *Root zone* usually yellower than the rest. Practically no *blackening* (slight in places but thinly diffused) ; *blushing* not apparent in the specimens.

Scar line rather distinct below the scarious edge of the leaf-scar, dark brown, sometimes interrupted immediately below the bud.

Ivory markings present in all parts, but the lower joints more often free ; usually of a few long dark lines in the middle of the cane and here passing through the bloom band or not ; in the upper joints a series of dark, parallel, sometimes anastomosing lines, in the upper two-thirds of the joints and passing through the bloom band. This form is very pronounced in *Bodi* where abundant splits occur. In *Dhaulu of Phillaur*, *splits* are also present but not so pronounced and arise from the ivory markings. *Groove marks* practically absent but the harsh black incrustation indicated here and there.

6. CHARACTERS OF THE JOINT.

Thickness, oralness.—The thickness probably varies a good deal in different fields, some of the lots of canes sent down being thicker than others. The following are the averages of 15 canes, medial + lateral :—

Base 0·59" + 0·64", middle 0·60" + 0·63", top mature 0·59" + 0·63". There appear to be little traces of *oralness* in any part, the cane being remarkably cylindrical.

Length of mature joints.—Average length in 18 canes 3·6", average longest 5·6", and average basal (shortest) 1·6".

Shape viewed medially.—Practically straight-sided, without prominent nodes; thickest at the leaf scar or region of the growth ring; root zone narrowing downwards, hence the whole joint possibly slightly narrowing upwards; younger, upper, immature joints distinctly bulged, especially in their lower third.

Shape viewed laterally.—Slightly zigzag with slight but distinct swelling below behind, the root zone taking part in the general downward curve; hence the whole joint long concavo-convex, the upper immature joints are more plano-convex, the thickening being behind.

Leaf-scar slightly but distinctly *descending*, especially in the upper joints; in the lower joints the scars tend to an alternately horizontal and descending position, as in many of the *Mango* group. Sometimes a distinct remnant of the leaf-scar forms a scarious *lip* under the bud. The *ending* is not decurrent.

Circlet of hairs present, short and numerous. Soon disappearing under the bud upwards on the cane, but some remains usually found right up the stem elsewhere, sometimes felt-like.

Groove absent.

Root zone, moderately wide, with moderately distinct eyes, widely separated and not forming definite rings, the lowest eyes often at some distance from the leaf-scar; two to three rows.

Growth ring rarely traceable as a distinct band; often practically absent, although the root zone has an upper boundary.

7. BUD.

Occasionally swelling below but hardly *shooting*; *bursting* more or less apically, but sometimes tending to a slightly dorsal opening.

Small, rounded, sometimes blackened above; not nearly reaching the growth ring except in young, upper joints.

Rising from the leaf-scar with occasionally a small, but distinct *cushion*.

Flanges, usually narrow borders round the upper part of the bud, rising high up, and often dark coloured ; in younger joints sometimes rising lower down ; never very prominent.

Bristles meagre, confined to a few strongish hairs round the apex ; *basal patches* usually absent, but occasionally indicated or even present ; *minute black hairs* present.

8. LEAF-SHEATH.

From the few sheaths attached to the canes sent down there appear to be a few *spines* on the back. The *ligule* is rather large and projecting upwards, rounded or angled broadly, with a fringe of longish silky hairs. These characters will need checking.

DESCRIPTION OF PLATE.

DHAULU OF PHILLAUR.

1, 2, 3, 4. Drawings made from one selected cane, the base, middle, and upper portions shown, as well as the end of the shoot. The buds are small and rounded, becoming elongated only near the tip (4a). Bursting is rather dorsal in the lower joints but soon becomes apical. The root zone is very wide but the eyes are rather irregularly disposed. The growth ring is practically absent, being occasionally indicated by a change in colour. The circlet of hairs is present only in the lower joints (1b) and soon disappears, and a sharply defined scar line is present. In the present case the scar line is interrupted under the bud but this is not usually so. The ivory markings are not common in the lower joints but increase in numbers upwards and there often pass through the bloom band and sometimes develop into splits. The leaf-scars are not accurately horizontal but are distinctly descending in places, especially in the upper joints.

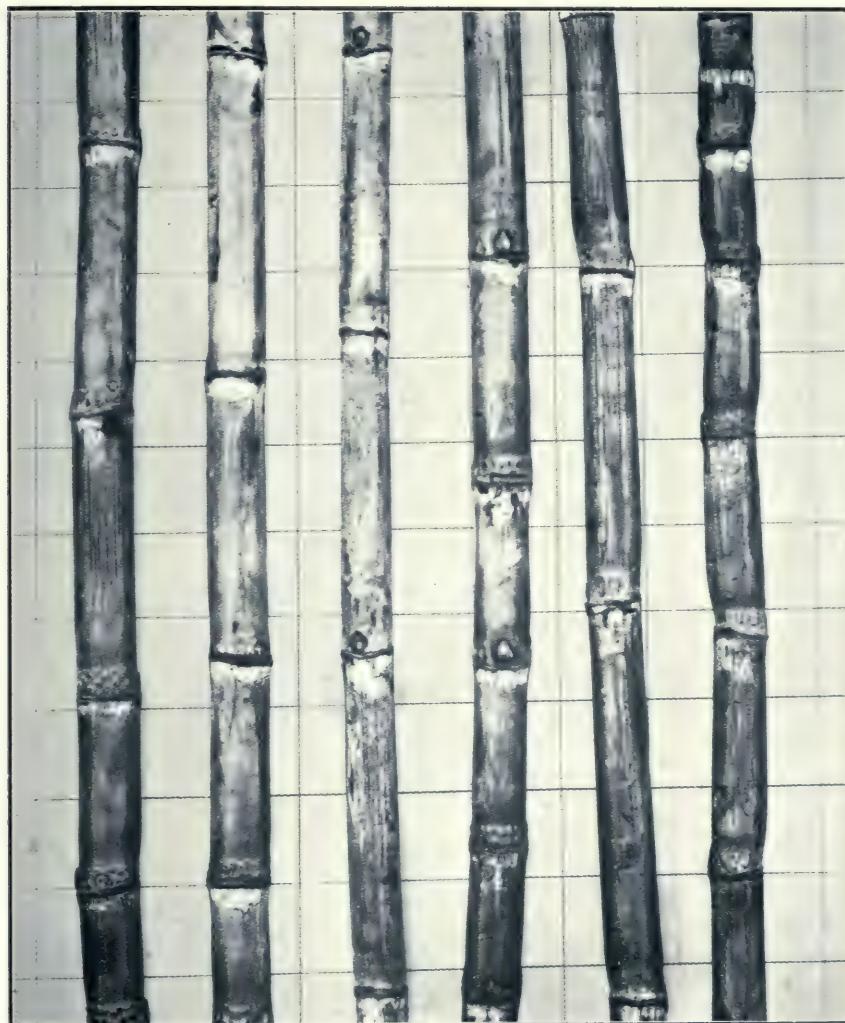
1a, 1b, 2a, 2b, 4a. Buds from various parts enlarged. The bud is not hairy ; a few bristles are seen, but basal patches are usually

absent; minute black hairs are present (base of 4a). The flanges arise high up and are frequently dark coloured, forming a sharply marked border round the upper part of the bud. In 4a the bud is elongated, as is usually the case so high up the stem, the flanges arise below the middle and there is a trace of cushion under the bud.

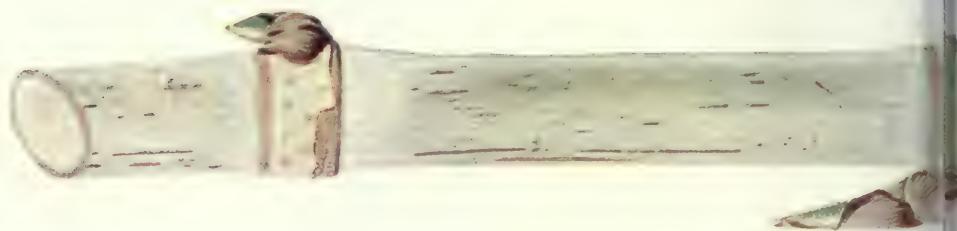
5. A couple of junctions of lamina and sheath. The specimens were dried up when they arrived but appear to show a small ligular process and a rather high, arched ligule. The hairs on the edge of the latter are longer than in the *Katha* group.



DHAULU OF PHILLAUR.



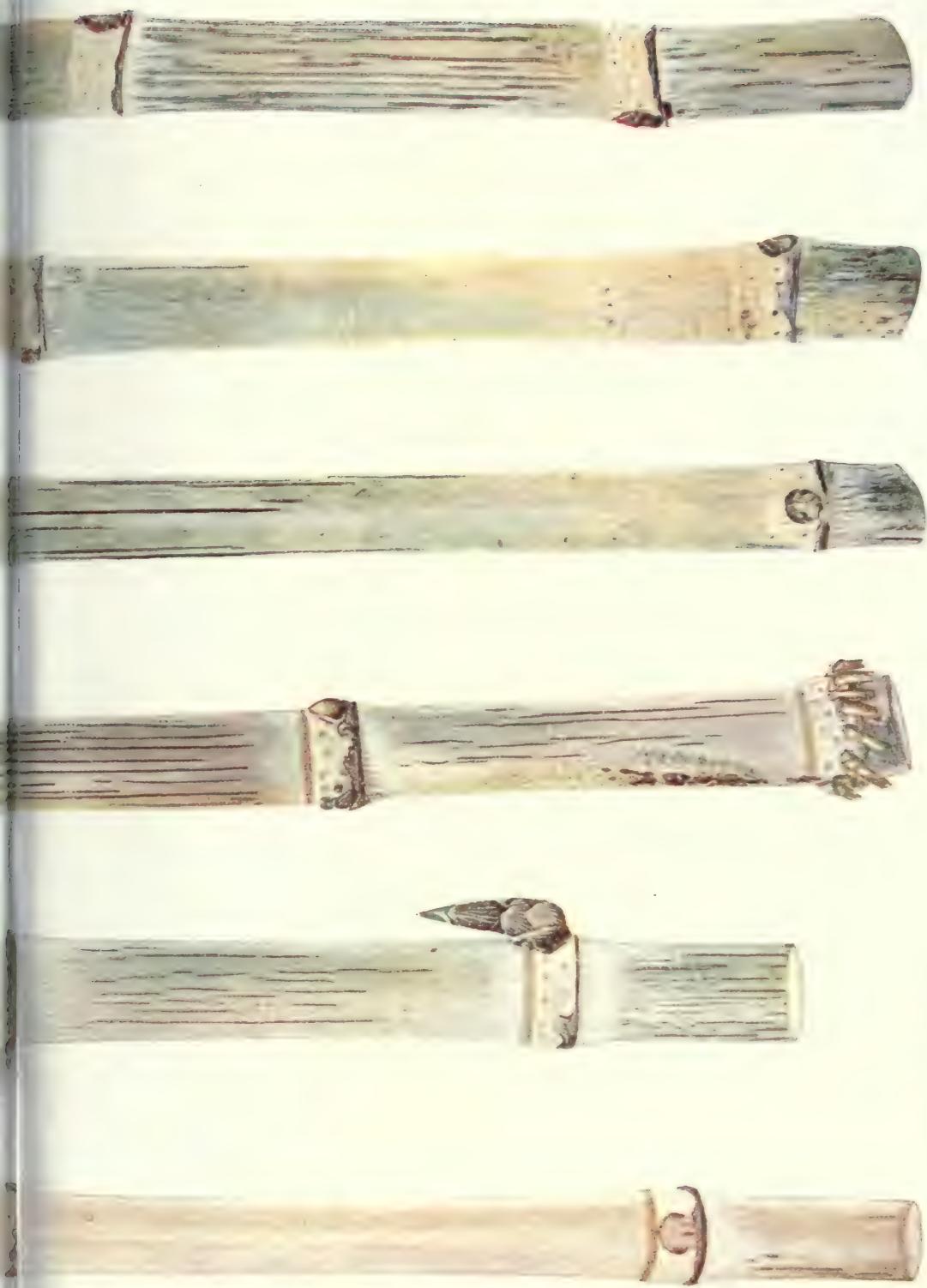
DHAULU OF PHILLAUR.



DHAULU OF PHILLAUR

TERERU

DHAULU OF GURDASPUR



KAHU.

1. GENERAL REMARKS ON DISTRIBUTION AND AGRICULTURAL AND CHEMICAL CHARACTERS.

A. *Kahu* is to be found widely distributed over the Province as a chewing cane near towns. As a gur-making cane it is practically confined to the Gurdaspur district, where the conditions for its growth are specially suitable. It is a green cane becoming paler on ripening, with broad leaves and a tall growing habit. It is the thickest cane in the Province from which *gur* is made. It requires more water, better land and cultivation than any of the other varieties and is subject to red rot. It ripens very late, yields very heavily and gives *gur* and *shakkar* of very superior quality. It has a soft rind which accounts for its being a favourite for chewing purposes.

(*Kahu* differs in many respects from all the other Punjab canes. It is the only *ganna* cane and, as these are frequently wiped out by disease, its susceptibility to red rot is explained. I have no information as to the migrations of this cane, but its allies are *Dikchan*, *Pansahi*, *Lata*, *Maneria*, *Chynia* and *Yuba*.—C. A. B.)

B. A soft, thick, juicy cane, yielding a poor quality of *gur* in frosty seasons ; it is planted mainly on canal irrigated land but is beginning to extend to *chahi* and *saitab* lands as well. The variety was classified as “ quickly affected by frost but quickly recovering ” in the season 1912-3, but this year has been “ non-resistant.”

The average composition of the juice (average of the last three years) is :—

Month.			Sucrose %	Invert sugar %
November	..	..	10.75	4.14
December	..	..	12.47	2.37
January	..	..	13.34	2.00
February	..	..	14.45	1.61

It is fully ripe about the end of January. The *gur* made from various specimens of the variety yielded a sucrose content of from 69·84 per cent. to 74·14 per cent.

(For sections A and B I am indebted to Messrs. Southern and Barnes respectively.)

2. LIST OF SPECIMENS EXAMINED.

Six months old.

(a) Gurdaspur, September 1913. Farm plot, irrigated ; 12 canes examined, of which 6 were carefully measured as to joints and foliage characters. Canes and leaves drawn and habit of the field photographed.

Ten months old.

(b) Gurdaspur, January 1914. Farm plot, irrigated ; 25 canes examined, of which 20 were measured as to thickness and length of joints. Canes drawn, painted and photographed to scale. Habit of the field photographed.

Twelve months old.

(c) Gurdaspur, March 1913. Bazaar canes (irrigated) ; 6 canes examined, drawn and photographed to scale.

(d) Gurdaspur, March 1913. Bazaar canes (rain-fed) ; 6 canes examined, drawn and photographed to scale. These canes appeared to be irregular and immature.

(e) Harchowal, March 1913. Cultivator's field ; 6 canes examined and photographed to scale.

Most attention was paid to the first four of these sets of canes.

3. GENERAL CHARACTERS OF THE VARIETY.

Kahu is a moderate sized, upstanding variety with a heavy top of foliage. The canes are thick as compared with others of the Punjab and the rind is soft. The joints are arranged in a zigzag manner, with slightly decurrent leaf-scar end, bulged above the growth ring which is depressed, with swollen root zones and prominent nodes.

The canes are glaucous green to yellow, blushing purple where exposed between the leaf-sheaths. Ivory markings are absent. The circlet of hairs is reduced to a few long stiff hairs under the buds. The buds are large, ovate pointed, exceeding the growth ring, often arising some distance above the leaf-scar and provided with a distinct cushion. Bristles fairly developed but basal patches often meagre, minute black hairs present especially in the lower parts. Leaves broad and curving broadly back, closing into a rather dense tuft at the top. Sheaths not clasping the shoot widely and with characteristic purple blotches while living. Ligular processes absent.

4. CANE MEASUREMENTS.

Dead leaves at six months old, 7 to 14, averaging 10.

Length of cane and of shoot after stripping these. Cane 2' 4", shoot 6' 4", suggesting late development.

Total length of cane and number of joints at six and ten months,

(a) 47·2" with 18·2 joints.

(b) 57·3" with 21·5 joints.

These figures show a marked difference from those of other Punjab canes and appear to strengthen the idea of late development. A good deal of growth apparently takes place after September.

Total length divided by average thickness at the middle, $l \div t$:—

(a) six months canes, 56. (b) ten months canes, 74, indicating that the September canes had not reached their mature form.

Length of joints in different parts of the cane, in inches :—

(a) Average of 6 canes. 1·9, 2·7, 3·1, 3·2, 3·2, 3·3, 3·3, 3·4, 3·5, 3·4, 3·2, 3·3, 3·2, 2·3, 1·7, 0·8, 0·4, 0·1.

(b) Average of 20 canes. 2·7, 3·3, 3·8, 4·2, 4·2, 4·1, 4·0, 3·8, 3·6, 3·6, 3·3, 2·9, 2·7, 2·3, 2·0, 1·6, 1·3, 0·9, 0·5, 0·3, 0·1.

On comparing these two series of figures we note, as we did in *Katha* and others, that they differ in two respects. In the first place, the older canes have a larger number of short joints at their ends,

the minimum 0·1" joint being much more gradually reached than in the six months canes. This we have put down to cessation of the growth in length at the end of the growing period. The older canes, in the second place, have, on the whole, longer joints at the base and sooner reach their maximum.

Thickness of the cane at various points.—The canes in *Kahu* are remarkably uniform in thickness in different parts. Occasionally they commence with half a dozen shorter joints, and these are narrow below and thicken upwards. Generally, there is a slight narrowing upwards in the upper half of the cane. The measurements of the 20 ten-months-canies were as follow:—

Base 0·75", middle 0·75", mature top 0·72".

5. COLOUR OF CANE.

The cane in *Kahu* is of a glaucous green or yellow colour, the skin being light green or yellow under the bloom. The joints are yellower at the base. The youngest ones in the terminal shoot are apple green before the bloom appears in any quantity. The *bloom band* is moderately distinct as a band descending over the joint, even the growth ring occasionally having scales of wax on it.

The *growth ring* is green to brownish yellow according to age, but it is not a very marked layer. The *root zone* is cream coloured to stone yellow and ultimately brownish yellow, sometimes heavily bloomed.

Blackening is frequent, especially at the top of the joints where the bloom is greatest, these two being inter-dependent. *Blushing* of the joints is a constant character, those exposed to the light between the leaf-sheaths assuming a dark purple due to a brown skin under the bloom.

There is a *scar line* rather than a *scar band* above the bloom layer, but it is light in colour and not very pronounced. *Ivory markings* are apparently absent, as well as *splits*. The *groove* appears to be without marks of any significance,

6. CHARACTERS OF THE JOINT.

Thickness, ovalness.—Average thickness in the specimens examined, lateral + medial :—

- (a) 12 canes 0·36" to 0·88", averaging 0·84".
- (b) 20 canes base 0·75" + 0·75", middle 0·75" + 0·78", top 0·72" + 0·76". Average thickness at the middle, 0·77".
- (c) 6 canes, thickest 0·81" + 0·83", thinnest 0·64" + 0·72".
- (d) 6 canes, thickest 0·81" + 0·78", thinnest 0·52" + 0·50" (im-mature).
- (e) 6 canes, thickest 0·82" + 0·84", thinnest 0·67" + 0·69".

These thicknesses show remarkable uniformity, allowing for the canes in (d) being unripe. There is also extremely little ovalness.

Length of mature joints.

- (a) average mature joint 3·2", average longest 4·6", average shortest 1·0".
- (b) average mature joint 4·7", average longest 6·0", average shortest 1·0".

Shape viewed medially.—The joints of *Kahu*, viewed medially, are more or less straight-sided in the middle, but, owing to the prominent nodes, assume a general biconcave aspect, especially in the shorter joints. There are, however, a number of characteristic local swellings common to many canes, which are somewhat pronounced in most *Kahu* stems. The following may be taken as a typical, well developed joint :—the leaf-scar is the thickest part ; above it a more or less protruding root zone narrows upwards in a symmetrical curve on either side ; the growth ring is usually thinner, perhaps the thinnest part of the joint ; immediately above it a slight symmetrical swelling of the lower part of the joint causes the growth ring to lie in a depression exactly as if a string had been tightly tied round the joint at this place ; the joint then narrows upwards with curved surfaces to just below the bloom band, which is again one of the thinnest parts of the joint ; from this point the joint thickens out broadly and symmetrically through the bloom band upwards to the leaf-scar.

As these local thickenings occur in various degrees in other canes, it may be found convenient to include them in one comprehensive term. Unfortunately there is no such term known to me in comparative morphology but, ignoring the root zone, we may perhaps describe the joint as "ovate campanulate." This portion has the form of an ornamental urn and the root zone has the appearance of a suitable pedestal for it to rest on.

The root zone is not swollen in the immature canes (*d*) and in these even narrows downwards. In the short joints at the base of the cane, the shape is so far altered that the joints are narrow below and thicken broadly upwards.

Shape viewed laterally.—The joints are markedly zigzag; the general shape is concavo-convex, with a distinct swelling below behind above the root zone. Where this swelling is not present the joints are biconcave, for instance in the young upper joints of the canes. The typical joint has its anterior surface concave and its posterior distinctly sigmoid.

Leaf-scars often slightly descending, with or without a short strong lip. The outer end of the leaf-scar is often dark and sharply marked and is sometimes distinctly decurrent.

Circlet of hairs not well developed in *Kahn*, being restricted to a few strong straight hairs under the bud below and soon disappearing upwards. There are usually no hairs at other parts of the circumference.

Groove fairly well marked in thicker canes, often not distinct in thinner ones.

Root zone bloomed, usually tubercled below, swelling bell-like downwards, sometimes flat or even narrowing downwards, but this is usually due to the joints being young and immature or poorly grown. There are two rows of large eyes or one large one below and smaller ones above. Ivory markings have not been noted in the root zone.

Growth ring not usually a very marked or wide ring; often narrow and inconspicuous and generally depressed. The lower

margin is usually well defined but the upper is often rather difficult to make out, except by the cessation of bloom and the consequent changes in colour. Waxy flakes of bloom have been noted in some parts of the cane on the growth ring.

7. BUD.

These were not infrequently *shooting* in the specimens examined, usually *bursting* at the apex. They are large, elongated, ovate, pointed, extending beyond the growth ring; they often rise above the leaf-scar and have in consequence a more or less developed *cushion*.

The *flanges* are regularly present, rather narrow and extending beyond the apex.

Bristles moderately developed, sometimes white and confined to the inner part of the flange; *basal patches* present or not, meagre, their place being sometimes taken by minute black hairs. *Minute black hairs* present, chiefly near the basal patches and sometimes taking their place.

8. LEAFY SHOOT.

Leaves moderately widely spaced on the stem but closing in at the upper end to a congested tuft, this being especially noticeable in the older canes where all the younger leaves are dead. Usually about 7 visible leaves in the *terminal tuft*, placed in the last two inches of the shoot.

Number of terminal joints under 2" long, 4 in the six months canes, 6 in the ten months.

(a) six months old 2·3", 1·7", 0·8", 0·4", 0·1".

(b) ten months old 2·0", 1·6", 1·3", 0·9", 0·5", 0·3", 0·1", showing the slower apical growth in the maturing canes.

9. LEAF-SHEATH.

Length of the sheaths in the young, vigorous, six months old plants; average of six canes, in inches:—8·0, 9·0, 9·1, 8·9, 8·9, 9·1,

$9\cdot4, 9\cdot3, 9\cdot4, 9\cdot3, 9\cdot3, 9\cdot6, 9\cdot5, 9\cdot1, 9\cdot2, 9\cdot1, 8\cdot8$ ($8\cdot2, 5\cdot5, 1\cdot0, 0\cdot3, 0\cdot1$).
Average longest in the six canes $10\cdot3''$.

The colour of the dead leaf-sheaths is perhaps slightly pink, but a good deal obscured by blotches of brown. The living sheaths are characteristically marked by dark purple stains, this colouration being seen in all the members of the class. They are rather heavily bloomed. The *scarious border* arises late and is apparently a result of the death of the edge of the lamina above it.

There are no *silicious spines*, but the surface is rough behind. The minute *hairs* between the veins behind are distinct under the lens and black coloured below. The base of the sheath does not *clasp* the stem widely.

Proportional width of sheath to lamina at junction :— $20 : 24, 18 : 22, 20 : 23$. As a natural consequence of these small differences, the *ligular processes* are absent. *Ligule* very narrow, with a lozenge in the middle, hardly clothed on the edge with minute hairs, which soon disappear.

10. LAMINA.

Width considerable, about $2''$ on the average, the maximum width varying from $1\cdot8''$ to $2\cdot2''$ in the six canes examined.

Length. Average lengths of lamina in six canes, $2' 0'', 2' 6'', 2' 11'', 3' 0'', 3' 2'', 3' 2'', 3' 3'', 3' 5'', 3' 5'', 3' 6'', 3' 9'', 3' 11'', 3' 10'', 3' 10'', 4' 0'', 4' 0'', 4' 0''. Average longest $4' 2''$.$

These are the visible leaves. It is quite probable that greater lengths might have been reached later in the season.

Proportion of length to width, 23 to 1, very different figures from those usual in the Punjab canes.

Not *channelled*; slightly, loosely embracing the shoot at the base, the edges sinuate at the base. *Transverse marks* dull or brownish green, varying. *Serrature* at middle harsh persistent, of short, sharp, close-set, rather straight, low-lying spines.

Proportional width of mid-rib to lamina, at base, $0\cdot20 : 1\cdot50$, at $1''$, $0\cdot20 : 1\cdot53$, at $6''$, $0\cdot20 : 1\cdot56$, at $12''$, $0\cdot19 : 1\cdot75$.

DESCRIPTION OF PLATE.

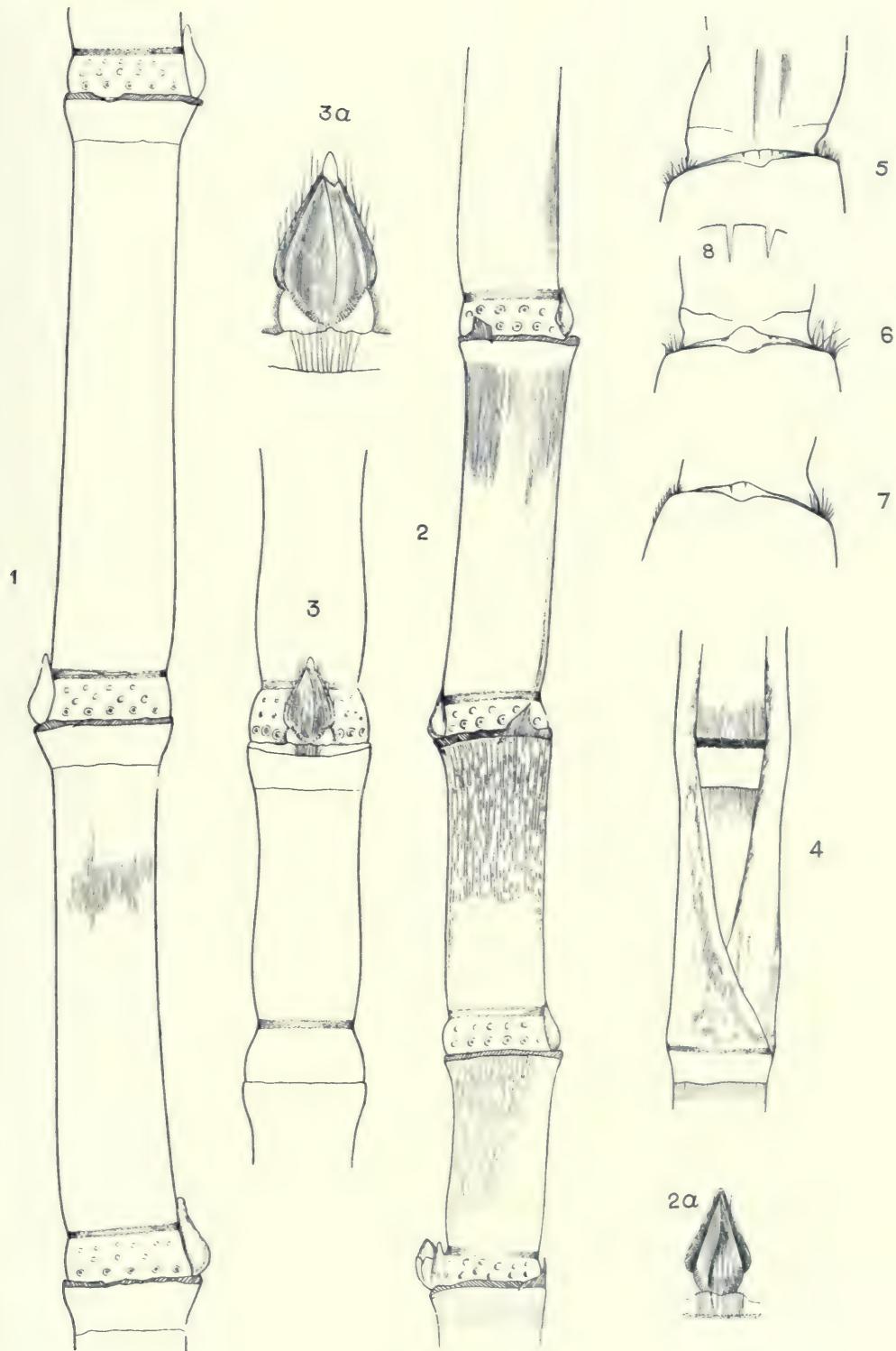
KAHU.

1. Joints of a six months cane. These are concavo-convex, with a swelling below behind. They are zigzag but the leaf-scar is practically horizontal. The root zone is swollen, increasing in thickness downwards. The growth ring is narrow and depressed. The bud is large and bulged below; its tip projects beyond the growth ring. There is a distinct, blunt shelf or ledge under the bud forming a truncate lip. The circlet of hairs is not in evidence.

2. The lower part of a ten months cane. It is blackened below, especially in the upper part of the joint. The characters noted above are maintained. The leaf-scar ending is distinctly decurrent for a short distance, as seen in the two upper nodes. 2a is the enlarged bud of the top joint.

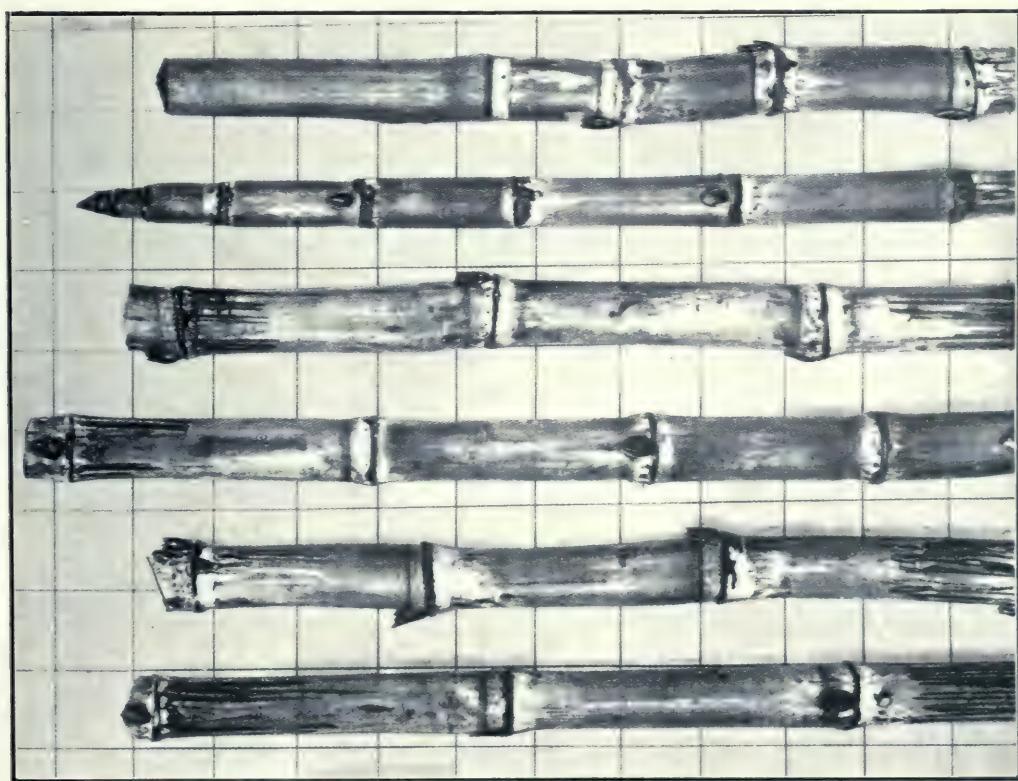
3, 3a. Medial view of a couple of joints of a ten months cane. The characteristic shape of the joint is seen from leaf-scar to leaf-scar; this has been called ovate campanulate above the root zone and the latter thickens bell-like downwards. The remnant of the circlet of hairs is seen as a few strong bristles under the bud. There is a well-marked cushion, the bud rising at a little distance above the leaf-scar. The bud bursts apically and is ovately elongated or even triangular. The flanges arise low down and form a narrow border to the upper part of the bud. Hairs are not very pronounced but bristles and basal patches are present.

4. The upper part of a ten months cane showing the leaf-sheath clasping the stem narrowly. The base of the lamina is not very much narrower than the leaf-sheath and there are no ligular processes. The ligule is narrow but has a lozenge-shaped expansion in the middle. The hairs on its edge (8) are meagre and quickly disappear.





KAHU, GURDASPUR, 6 MONTHS OLD.
(The white mark on the bamboo is just under 6 feet.)



KAHU, GURDASPUR.
(The streaks at the ends are not ivory markings but scratches in the surface.)

KANARA OF JULLUNDER.

1. GENERAL REMARKS ON DISTRIBUTION AND AGRICULTURAL AND CHEMICAL CHARACTERS.

A. *Kanara* is very little grown in the Punjab, although it is often seen in small quantities in the submontane tracts to the east of the Beas. It is an unimportant cane from the agricultural point of view.

It is slightly thicker than *Dhaulu* of Gurdaspur and ripens to a bright green colour. It is very seldom grown pure, has a soft rind and is mostly used for chewing. Owing to its soft rind it is very liable to be wiped out by frost, which happens periodically in severe winters. (*Kanara* is interesting from the morphological point of view and appears to me to present several primitive characters. In the Introduction I have stated the case for its periodic introduction from the neighbourhood of Meerut, but its very narrow leaves and the persistence of the circlet of hairs bring it near to the primitive *Katha* canes and it is possible that it, like *Katha* and *Dhaulu*, may have been derived from *Saccharum spontaneum*. I look forward to tracing its relationships in other Provinces and may some day be able to suggest a line of development divergent from those given for *Katha* and *Dhaulu* to thicker canes further east.—C. A. B.).

B. A cane which, being harder than *Dhaulu* and softer than *Katha*, gives a juice of high specific gravity, but yields a less quantity under the iron *belna* than all of the other seven types under report. It is new to the District and was planted on the Farm in the season 1913-4, when about half of the plot gave *shakkar*. The variety may be classified as semi-frost-resistant on the results of this season's experiments.

The average composition of the juice in the season was :—

Month.	Sucrose %	Invert sugar %
November	11.81	4.19
December	13.47	2.76
January	14.19	2.40
February	16.17	1.22

It is fully ripe about the middle of February.

(For the details in sections A and B, I am indebted to Messrs. Southern and Barnes respectively).

2. LIST OF SPECIMENS EXAMINED.

The specimens examined were from the farm plots at Gurdaspur for which the canes had been obtained from Jullunder.

Canes six months old.—(a) Gurdaspur, September 1913. Farm plot, irrigated ; 12 canes examined, six of which were measured as to their joints, leaf-sheaths and laminas. Canes drawn and field photographed.

Canes ten months old.—(b) Gurdaspur, January 1914. Farm plot, irrigated ; 25 canes examined of which 20 were measured as to their joints. Canes drawn, painted and photographed to scale and the field photographed.

3. GENERAL CHARACTERS OF THE VARIETY.

In minute points this cane seems to stand somewhat between *Katha* and *Dhaulu* of *Gurdaspur*. Canes moderately thin and often oval in section, grooved, straight, with shorter joints and more prominent nodes than in *Katha*, and therefore the joints biconcave, especially in medial view. Colour bright green, the bloom not descending much over the joint and thereby hiding the natural colour. Cut and stripped canes soon turn a bright red pink on exposure. The red brown marks in the groove seen in *Katha* are found in *Kanara*. There is either a scar line or a scar band. Ivory markings are not common but, when they occur, they frequently pass through the bloom band. Circle of hairs present,

persistent all the way up, the hairs becoming shorter and fewer upwards. Buds short, small, squared, not reaching the growth ring, bursting dorsally; not well provided with hairs, but minute black hairs present. The leaves are very narrow, although somewhat wider than in *Katha*; the young leaves resemble those of *Dhaulu* of *Gurdaspur* in being erect, strict, without bent tips. The lamina is rather channelled at the base, the leaf-sheath does not embrace the stem widely and the ligular processes are small or absent.

4. CANE MEASUREMENTS.

Dead leaves at six months old, average 10.

Length of six months cane after stripping dead leaves.—The canes averaged 2' 4", the shoot 6' 3". These figures suggest slow initial growth in this variety.

Total length of cane and number of joints, at six and ten months :—

Six months canes (a) 49·6" with 21·3 joints.

Ten months canes (b) 54·2" with 25·5 joints.

Total length of stripped cane divided by average thickness at the middle, l. ÷ t.

(a) 82, (b) 85.

Length of joints in different parts of the cane, in inches :—

(a) 1·3, 1·9, 2·4, 2·7, 3·0, 3·0, 3·1, 2·9, 3·1, 3·0, 3·1, 3·0, 2·9,
2·6, 2·7, 2·6, 2·1, 2·1, 1·1, 0·3, 0·1.

(b) 1·1, 1·5, 2·0, 2·4, 2·8, 3·0, 3·2, 3·3, 3·3, 3·1, 3·0, 3·1,
3·1, 3·0, 2·9, 2·6, 2·2, 1·8, 1·6, 1·3, 0·9, 0·6, 0·4, 0·2, 0·1.

A comparison of these two sets of figures shows at once how rapidly the end of the shoot is growing at six months and how slowly at ten. It is also to be noted that the basal joints of the ten months canes are not any longer than those at six months, as is the case so markedly in *Kahu* and *Lalri*. The two series of measurements are so similar that we can readily believe that we are dealing with the same set of canes at different periods of growth, the measurements running parallel until we come to the terminal shortening

region. Turning to the full list of measurements of which these are the averages, we do however find the two classes of canes noted in *Kahu*. There is one cane with far fewer joints than the rest, and it has long basal joints, and there is also another with an average number of joints which shows a similar tendency. The figures for these two are given below and show that they are fairly comparable, but that one has an unusually large number of short terminal joints :—

No. 11. 2·7, 3·3, 3·6, 4·1, 4·1, 3·8, 3·5, 3·4, 4·3, 4·3, 4·4, 4·5, 2·2, 2·0, 1·9, 1·0, 0·5, 0·3, 0·1.

No. 6. 2·5, 3·1, 3·3, 3·4, 3·8, 3·5, 3·4, 3·1, 3·9, 4·1, 2·6, 2·2, 2·5, 2·2, 1·8, 1·9, 1·8, 1·2, 1·2, 1·0, 0·6, 0·5, 0·3, 0·2, 0·1.

But the great majority, 18 of the 20, have short basal joints, gradually increasing in length as in the typical six months canes. From this we are, I think, justified in gathering that the *Kanara* canes are rather late in developing, and there is little of the distinction between early formed and late formed canes which we note in certain other varieties.

Thickness of the cane at various points.—The canes are practically uniform, excepting that the lower joints are sometimes short and narrow, each joint thickening from base to top. Average thickness in (b), at base 0·60", at middle 0·60", at top 0·62".

5. COLOUR OF CANE.

Canes green or yellowish green, being yellower in the lower parts of the joints. The youngest joints are of a clear apple green. The *bloom band* is moderately distinct, especially in the greener joints but descends comparatively little over the joint, thus readily distinguishing this cane from the usual glaucous green ones of the tract. This colour makes it easy at once to pick out the *Dhaulu* admixture in *kanara* plots. *Blackening* is not markedly present. The canes *blush* readily to a rather bright red pink after cutting. The *growth rings* are greenish to yellowish brown according to age and the *root zone*, similarly, greenish yellow to bone yellow. A *scar*

line is sometimes present of a light brown colour, but a *scar band* is also sometimes met with. *Ivory markings* are not very common and these often pass through the bloom band. In the youngest parts of the cane there is often a joint with many close parallel lines in the middle of the joint, as in so many other kinds of canes. The young parts are often *split* in the covered-up bud portion. The *groove* not infrequently shows the red brown marks which have been taken to be characteristic of the *Katha* alliance as contrasted with the *Dhaulu*.

6. CHARACTERS OF THE JOINT.

Thickness, ovalness.

(a) Average of six canes at the middle, lateral+medial $0\cdot57'' + 0\cdot64''$.

(b) Average of 20 canes, base $0\cdot60'' + 0\cdot60''$, middle $0\cdot62'' + 0\cdot60''$, mature top $0\cdot61'' + 0\cdot67''$. These figures suggest an *oval cane* and this character is seen, the moment the canes are cut and stripped.

Length of Mature Joints.

(a) Average $2\cdot66''$, average shortest (basal) $1\cdot3''$, average longest $3\cdot5''$.

(b) Average $2\cdot63''$, average shortest (basal) $1\cdot1''$, average longest $3\cdot8''$.

Shape viewed medially.—Slightly biconcave, the growth ring being the thinnest place and the joints gradually thickening upwards; root zone slightly swollen and the leaf-scar the thickest part. Hence the joint is elongated campanulate above the root zone, and differs from *Kahu* chiefly in the less prominent nodes and the absence of the swelling above the growth ring.

Shape viewed laterally.—Slightly thickening upwards, biconcave or concavo-convex, according to the development of the slight thickening below behind. The relative thickness of parts in other respects is similar to that in the medial view.

Leaf-scar, practically horizontal but occasionally slightly descending, and without definite *lip*.

Circlet of hairs present and persistent most of the way up. Getting shorter and more meagre upwards.

Groove rather distinct, narrow, all the way up the joint. Sometimes with a rather deep depression above the bud and not infrequently with the brown red mark characteristic of *Katha* canes.

Root zone not wide, usually slightly swollen, bell-like, downwards; eyes hardly tubercled, in 2-3 moderately distinct rows.

Growth ring narrow, flat to slightly raised, but lower than root zone.

7. BUD.

Shooting not noted; *bursting* dorsally.

Short, small, squared, sometimes protruding hemispherically, not reaching growth ring.

Arising close to the leaf-scar which has often to be removed to note the characters of the small bud.

Flanges small and not very conspicuous, rising rather high up, narrow below but broad and often squared above the apex.

Bristles not pronounced; *basal patches* poorly developed or absent; *minute black hairs* present.

8. LEAFY SHOOT.

Leaf end not apparently bent as in *Katha*.

Number of terminal joints under 2", 3 at 6 months and 8 at 10 months.

(a) 2·1, 1·1, 0·3, 0·1.

(b) 2·2, 1·8, 1·6, 1·3, 0·9, 0·6, 0·4, 0·2, 0·1.

These figures show, in a pronounced manner, the slowing down of apical growth towards the end of the season, and are perhaps characteristic of a shorter-jointed cane than *Katha* and *Dhaulu*.

9. LEAF-SHEATH.

Length.—Average length in six months canes, in inches:—

(a) 8·2, 8·8, 9·7, 9·9, 10·3, 10·6, 10·6, 10·8, 11·0, 11·0, 10·9,
11·1, 11·1, 11·3, 11·2, 11·3, 11·3, 11·2, 11·0, 11·1,
(10·4, 9·0, 2·2, 0·3, 0·1, in bud).

Longest sheaths in the several canes 12·4", 13·3", 10·8", 12·4", 11·5", 11·6". Average longest 12·0".

Not bloomed, with clear parallel veins, those recently dead not becoming clear crushed strawberry coloured.

Scarious border apparently forming rather early and before the death of the lamina edges; *edges* of the upper, younger leaf-sheaths frequently browned.

Hairs at junction of leaf-sheath and lamina descending along the edge of the sheath; hairs between the veins behind just visible under the lens, blackened below.

Base of the leaf-sheath not *clasping* the shoot widely, practically as in *Dhaulu*.

Proportion of base of lamina to top of leaf-sheath; rather varying in the specimens examined, 10:13·5, 11·5:13·5, 10·5:15·5. This last one, as might be expected has a small ligular process. These figures require checking in further specimens.

Ligular processes absent, indicated or small.

Ligule narrow, not indented below, with a fringe of smallish but distinct hairs.

10. LAMINA.

Width, usually under 1", but occasionally reaching that figure.

Length in the six shoots examined including all leaves with visible tips; averages from base upwards:—

2' 2", 2' 3", 2' 4", 2' 10", 2' 8", 3' 2", 3' 2", 3' 2", 3' 5", 3' 5", 3' 6", 3' 2", 3' 2", 3' 7", 3' 7", 3' 8", 3' 8", 3' 8", 3' 9", 3' 8", 3' 8", 3' 8", 3' 8", 2' 7", 1' 10".

Average longest in these six canes 3' 10".

Proportion of length to width, 46 to 1.

Rather *channelled* at the base, slightly, loosely embracing the stem.

Transverse marks dull blackish green, lightly bloomed.

Serrature harsh persistent, made up at middle of minute, scattered hairs.

Proportional width of mid-rib to lamina.

At 1" from base, 0·20:0·50, at 6", 0·16:0·55, at 12", 0·14:0·75.

DESCRIPTION OF PLATE.

KANARA OF JULLUNDER.

1. Portion of a six months cane. The root zones are rather narrow but the buds are very small and do not reach the growth ring. The latter is distinct and narrow and not very deeply coloured. The circlet of hairs is well marked.

1a. Medial view of the middle node of 1, and 1b, the bud enlarged. The bud is circular with a flat top formed by the narrow flanges which arise about the middle. Bursting is markedly dorsal. The bud is sunk in a rather pronounced depression at the base of the groove. A comparison of 1 and 1a, shows that the cane is oval in section.

2, 3. The base and top of a ten months cane. The characters noted above are maintained. The root zone is narrow and rather swollen downwards. The buds are very small, rounded or flat-topped and bursting dorsally. The circlet of hairs, well developed and persistent most of the way up is only present here and there at the top. The ivory markings are sparse below and pass through the bloom band above. One joint has a mass of ivory markings, as in *Katha*, but these extend here almost the whole length of the joint, instead of being confined to one part, as in *Katha*.

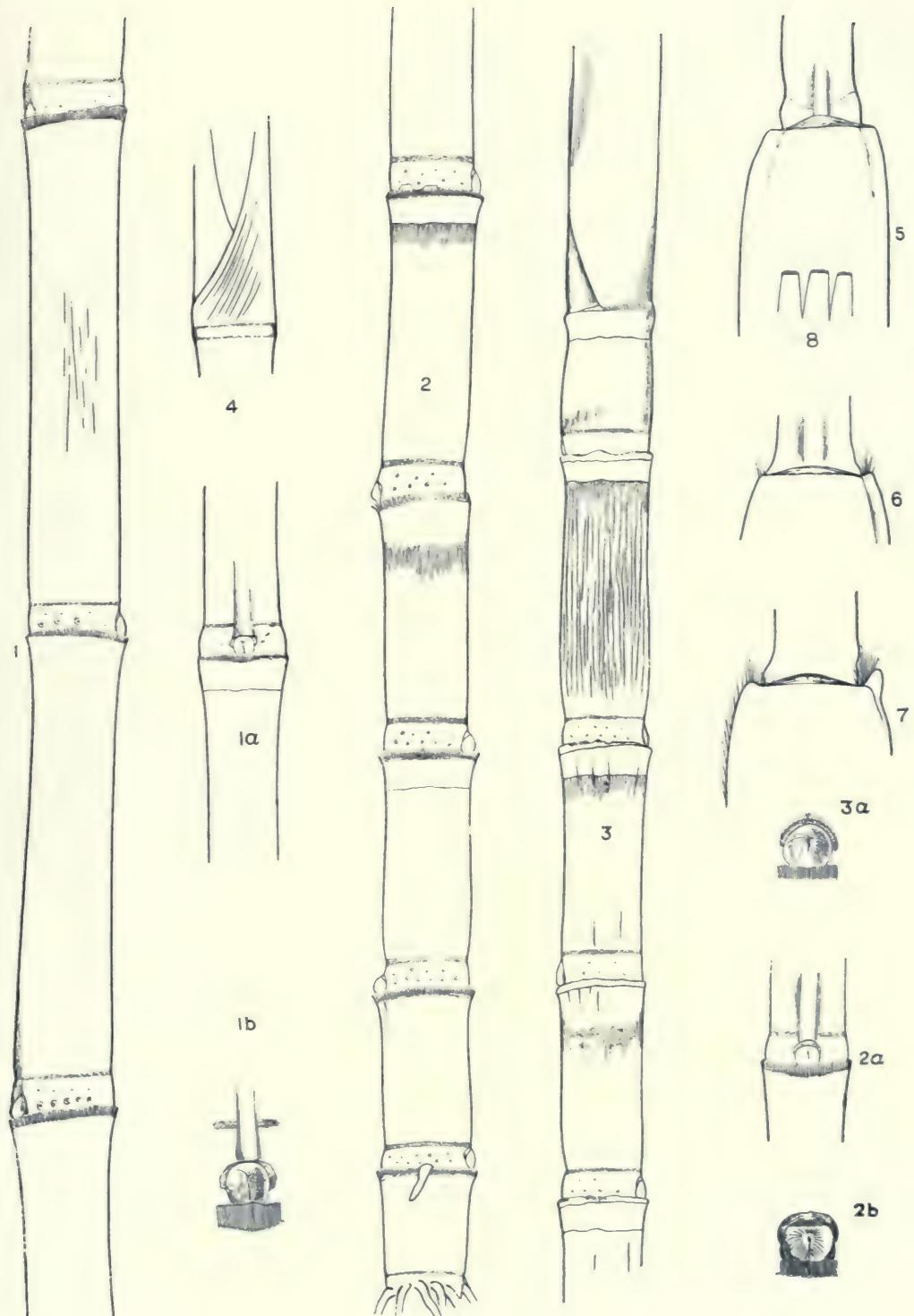
2a, 2b, 3a, buds of 2 and 3. The vestiture of hairs is not very well developed, but varies.

4. The top of a six months cane, showing the leaf-sheath clasping the stem widely at the base.

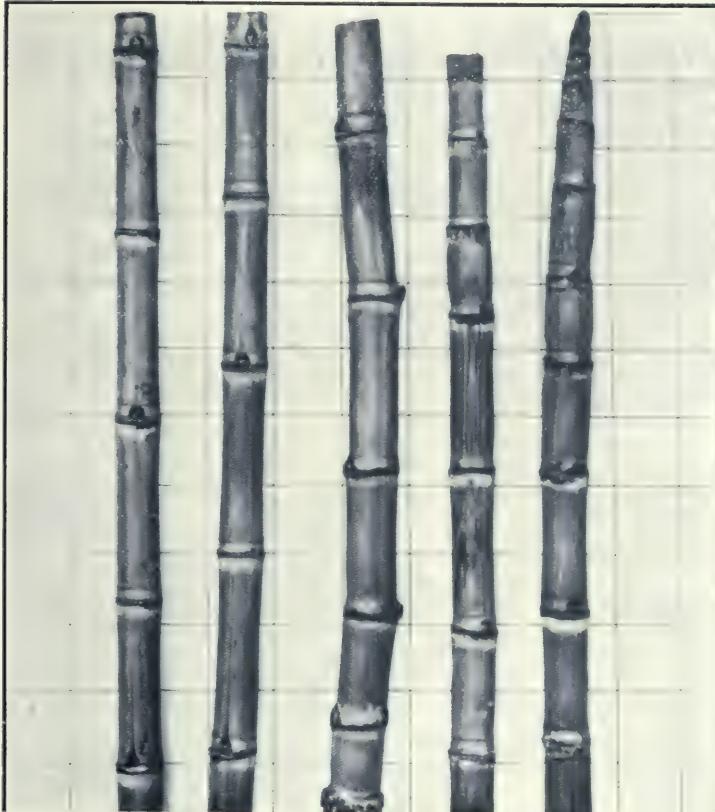
5, 6, 7, 8. Junction of lamina and leaf-sheath. Ligular processes are small or absent and the tuft of hairs descends along the edge of the leaf-sheath in 7. The ligule appears to be rather narrow. The hairs on its edge (8) are minute.

COIMBATORE,

April, 1914.



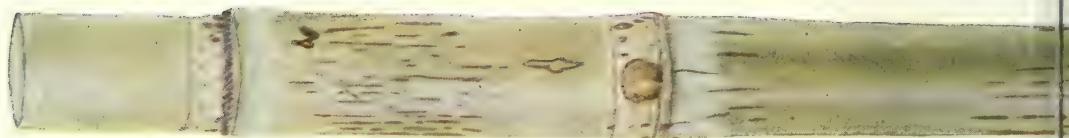
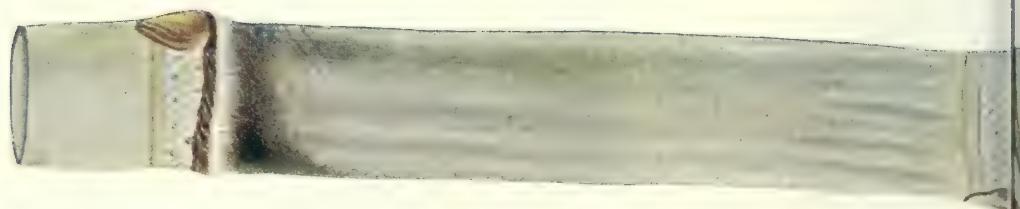
KANARA OF JULLUNDER.



KANARA OF JULLUNDER.



KANARA OF JULLUNDER, 6 MONTHS OLD.
(The black mark on the bamboo is just under 6 feet.)



KAHU

KANARA OF JULLUNDER

